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G02B 26/10, G06K 7/10

(52) UK CL (Edition K)
G2J JB7WX
G4M MBF MB4
U1S S2120

(56) Documents cited

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EP 0295936 A2	EP 0224996 A2	EP 0032117 A2
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(58) Field of search
UK CL (Edition K) G2J JB7WX, G4M MBF
INT CL^5 G02B

(54) **Laser bar code scanner producing parallel scan lines**

(57) A laser scanner produces generally parallel scan lines at a target by moving, by dithering, rotating, translating, or wobbling a secondary mirror 51B, 132, optical device, or primary optical element in an optical arrangement which redirects a laser light beam to generate a scan pattern. The laser scanner typically includes an optical device 36 or primary optical element which receives and reflects laser light beams from a laser light source, and a multiplicity of secondary mirrors 51 disposed in positions relative to one another. One or more of the secondary mirrors 51B are mounted and dithered or continuously rotated to generate the scan lines. Other optical elements, such as a primary optical element or device may be rotated, dithered or wobbled in their mountings to produce the scan lines.

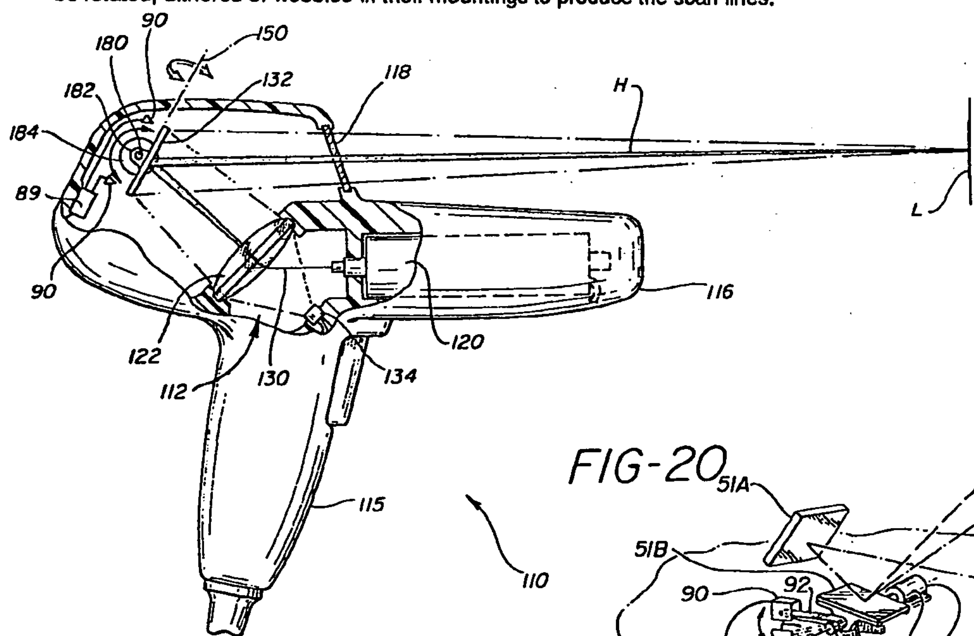
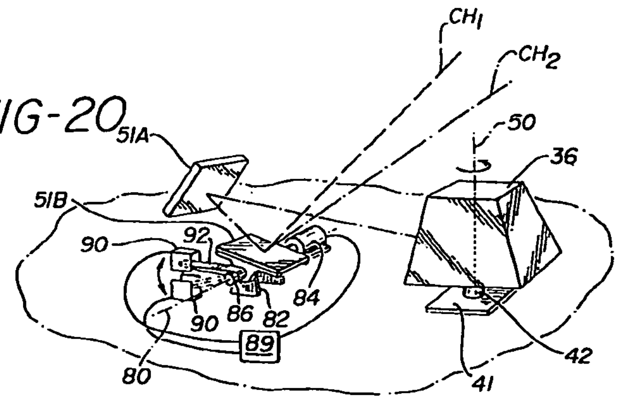


FIG-20

FIG-8



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 255 650 A

FIG-1

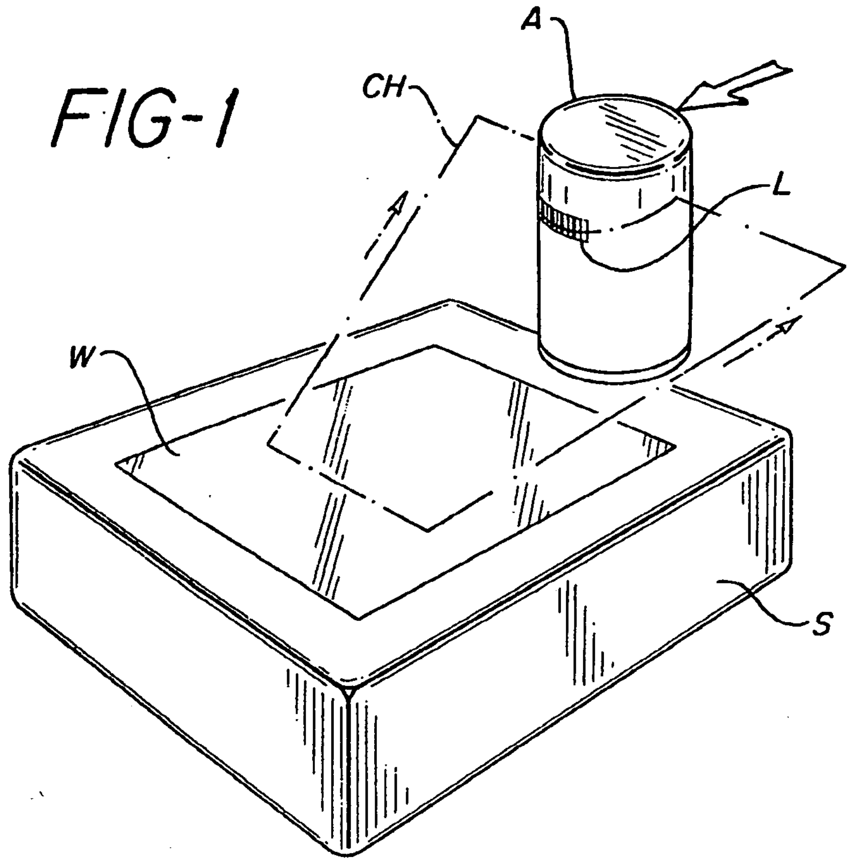


FIG-2

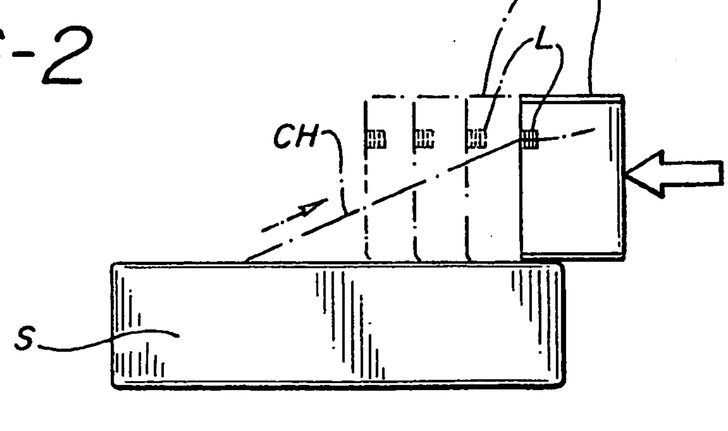


FIG-3

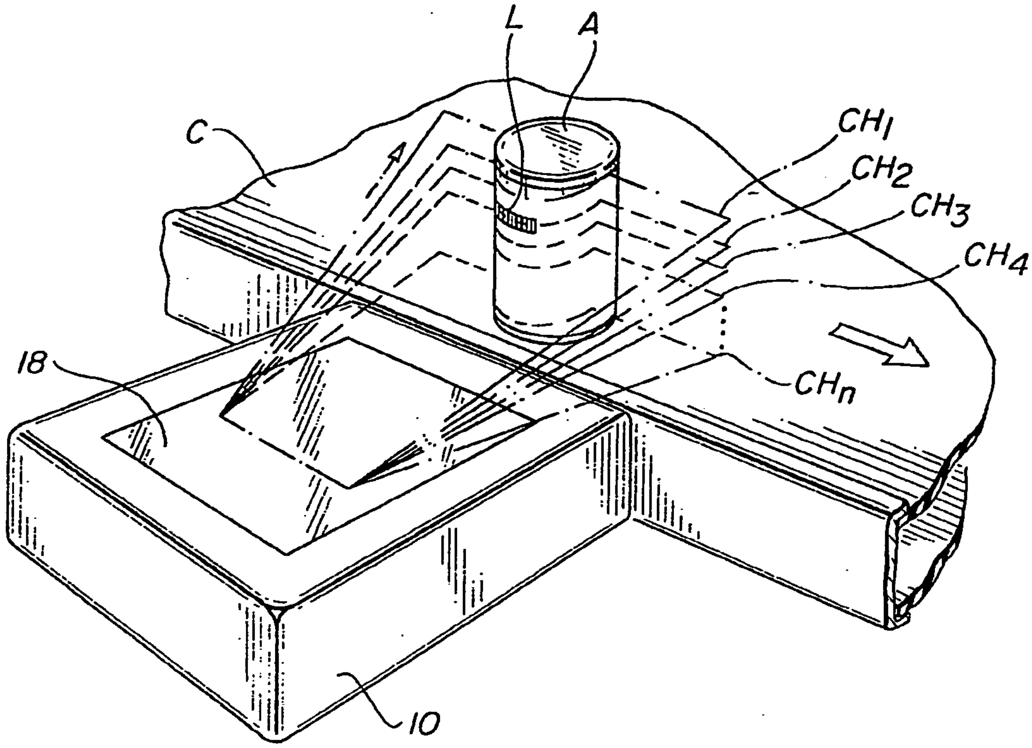


FIG-4

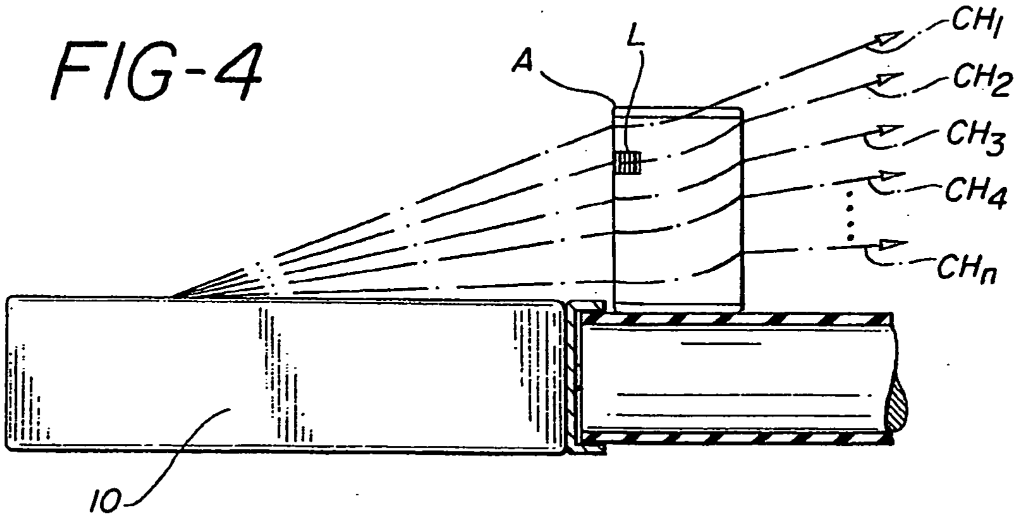
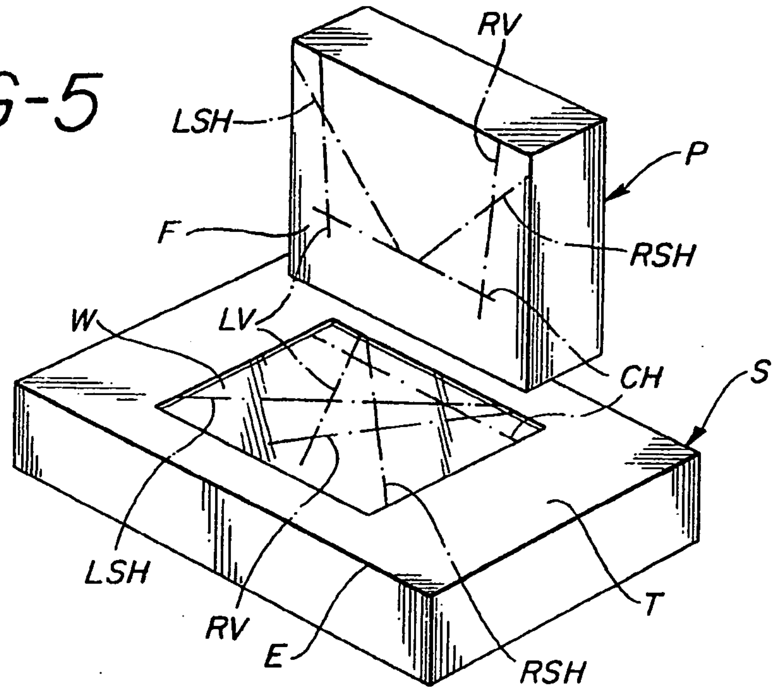


FIG-5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LSH
P
F
RSH
W
LV
CH
S
LSH
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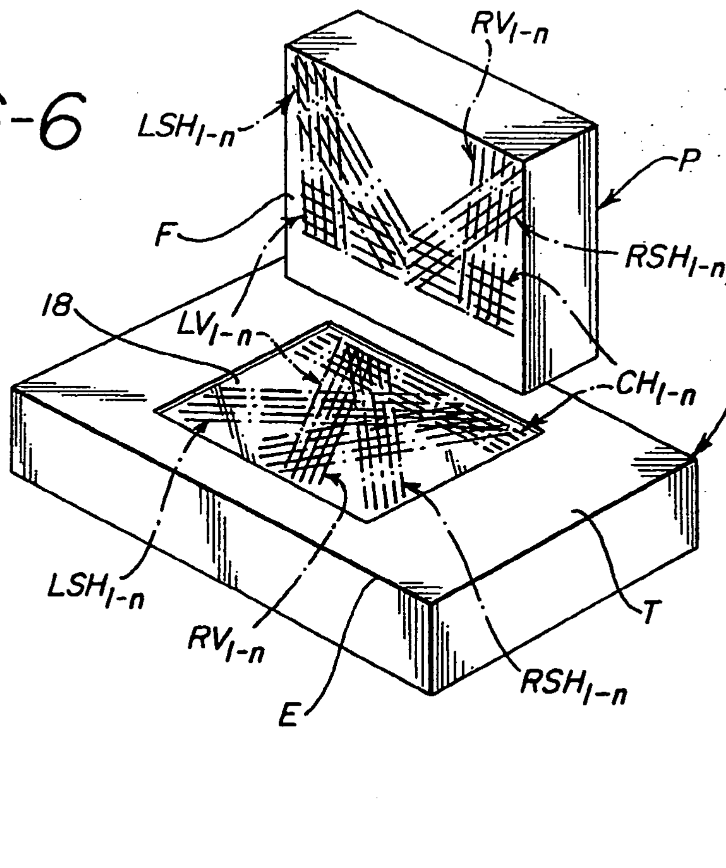
T

FIG-6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LSH_{1-n}
P
F
RSH_{1-n}
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CH_{1-n}
10
LSH_{1-n}
RV_{1-n}
E
RSH_{1-n}
T

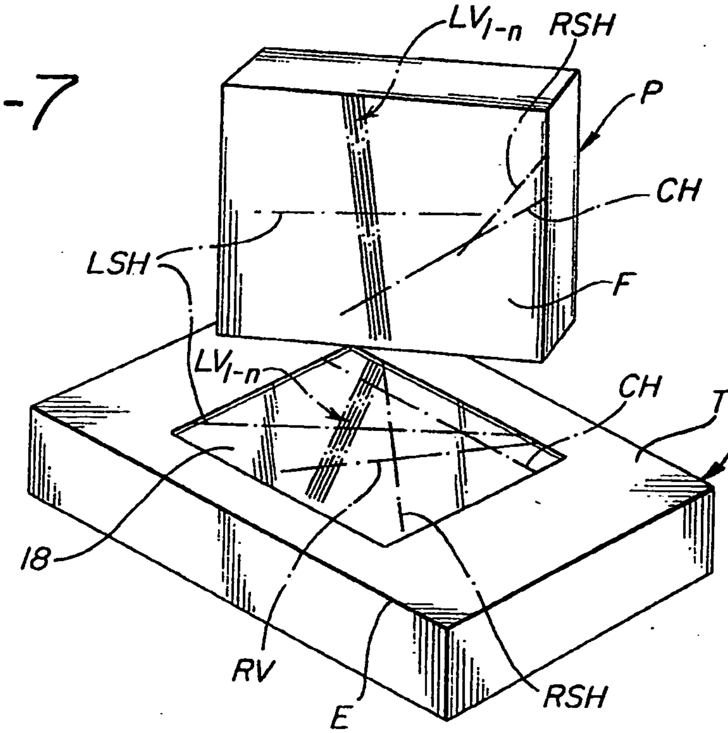
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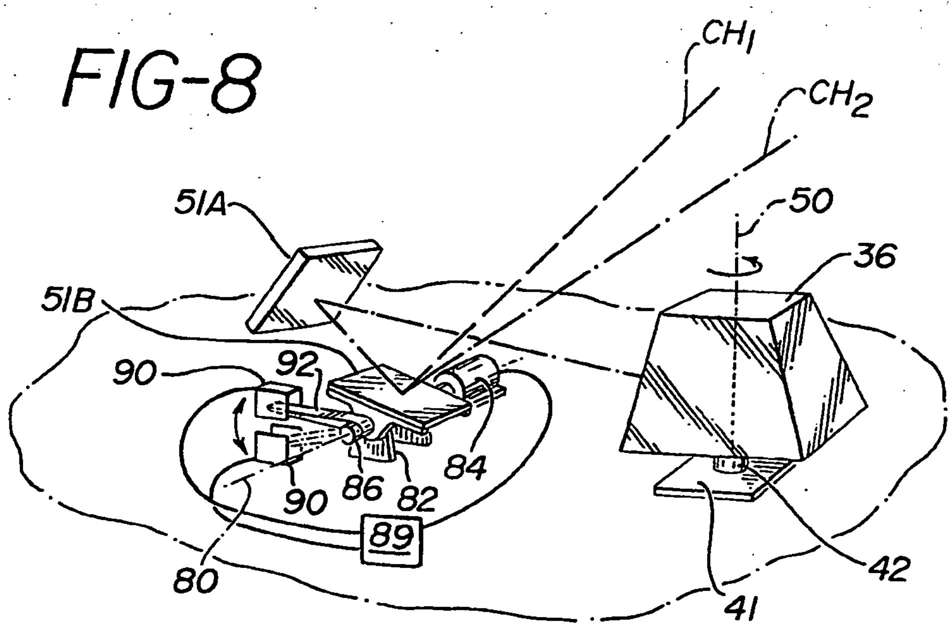
FIG-7


CH1
CH2
51A
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36
51B
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86
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89
80
42
41

FIG-8

FIG-9

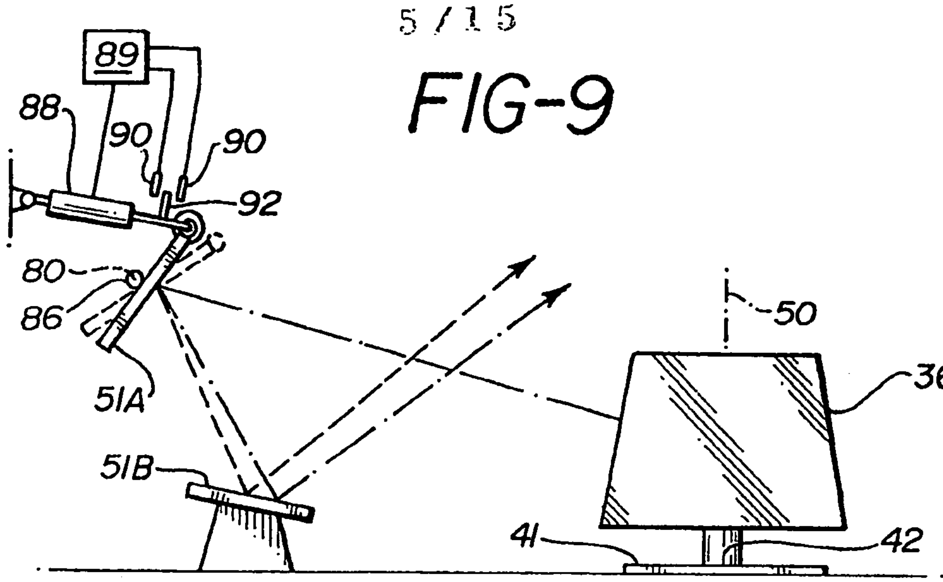


FIG-9B

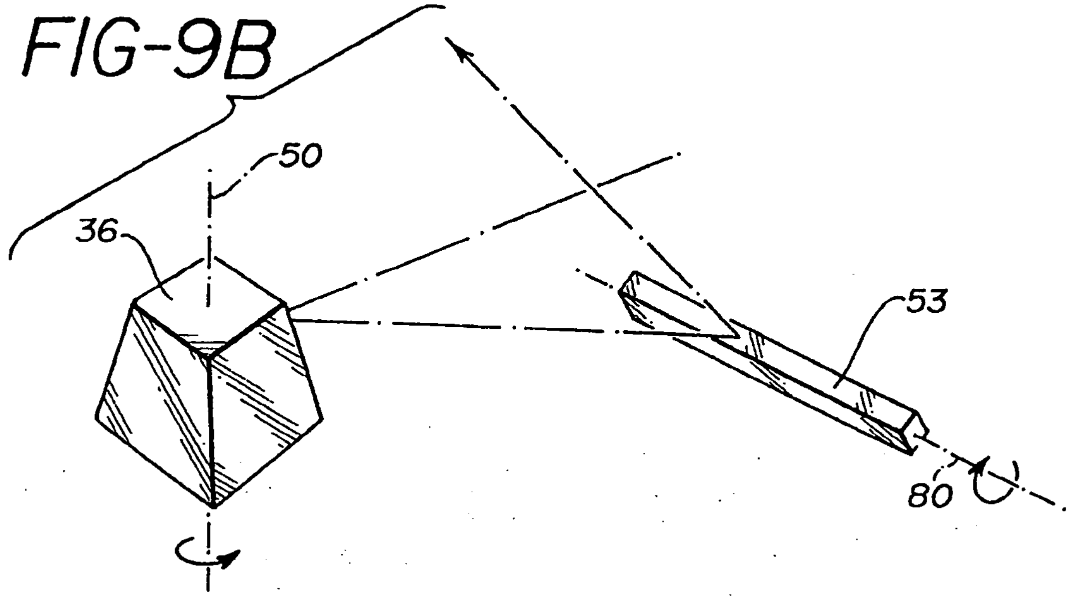


FIG-10

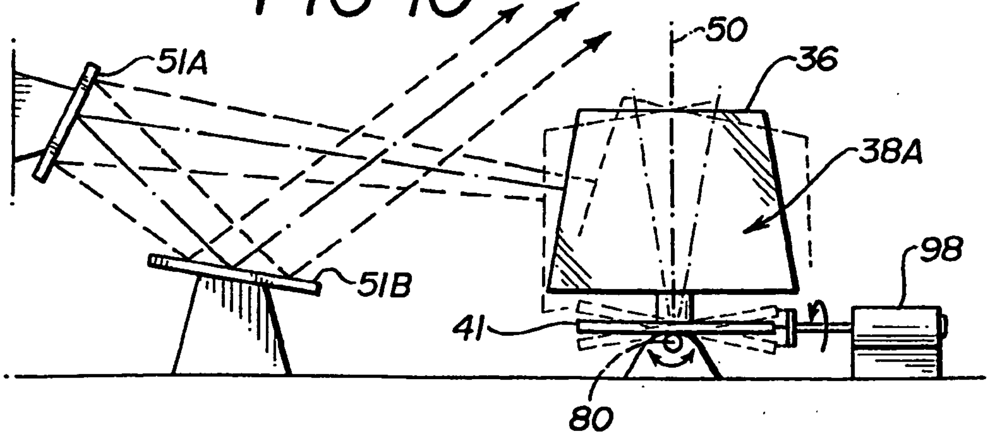
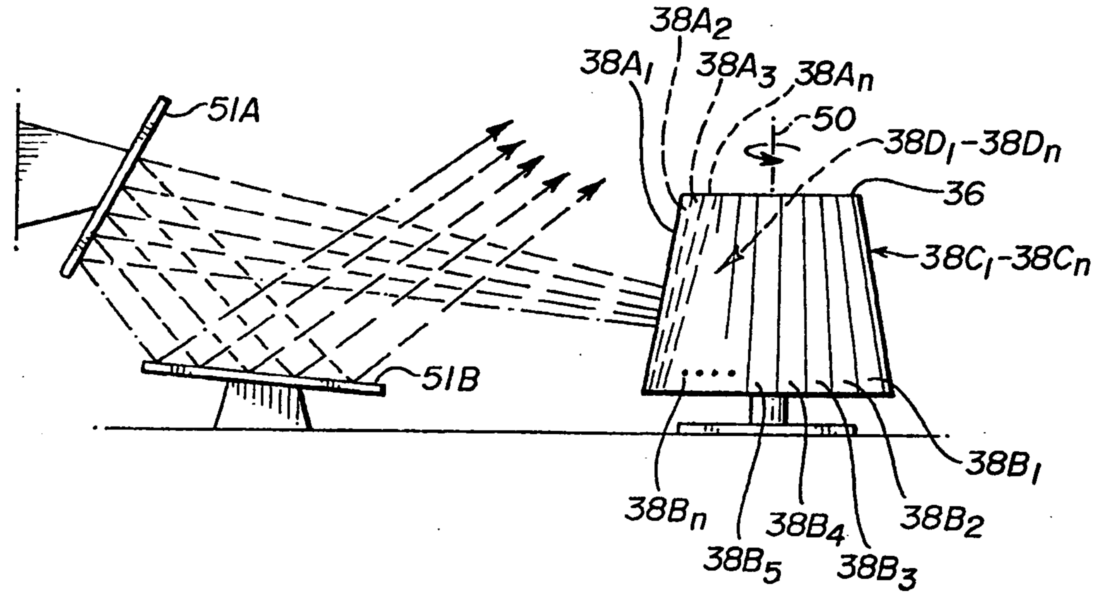
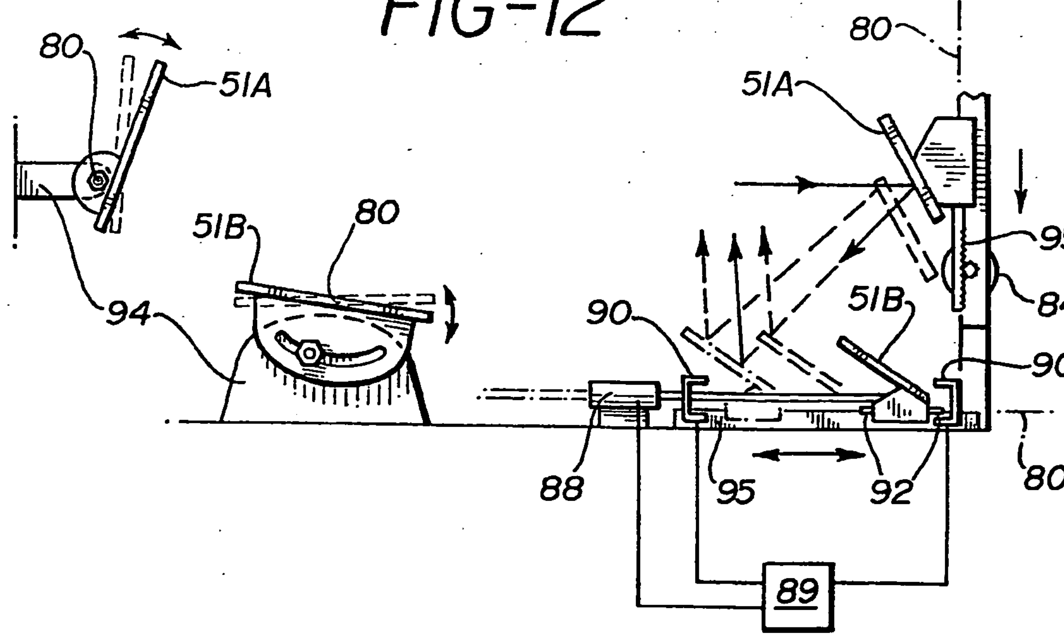


FIG-11



51A
51B
38A2
38A1
38A3
38An
50
38D1-38Dn
36
38C1-38Cn
38B1
38Bn
38B4
38B2
38B5
38B3

FIG-12



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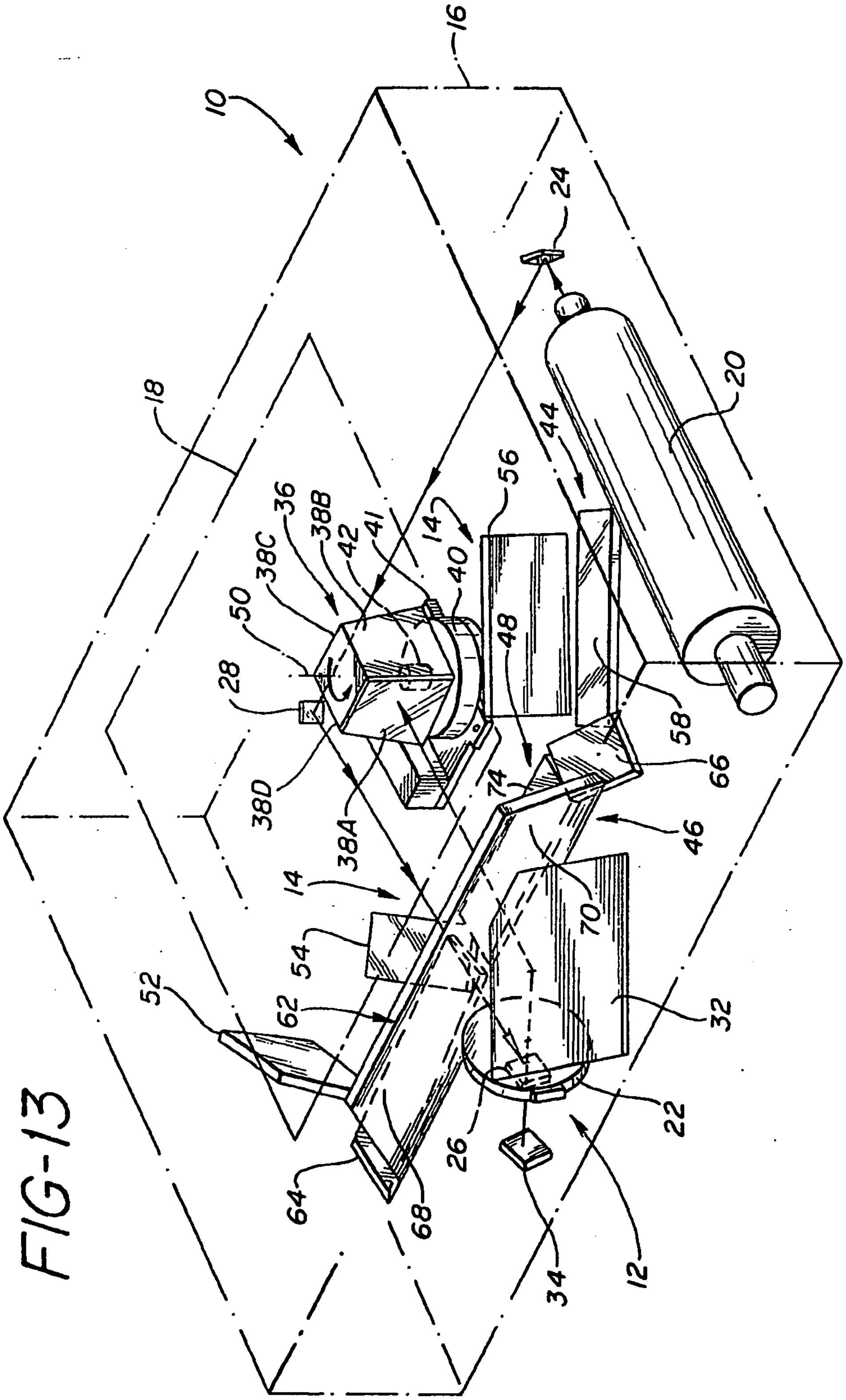
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38C
38B
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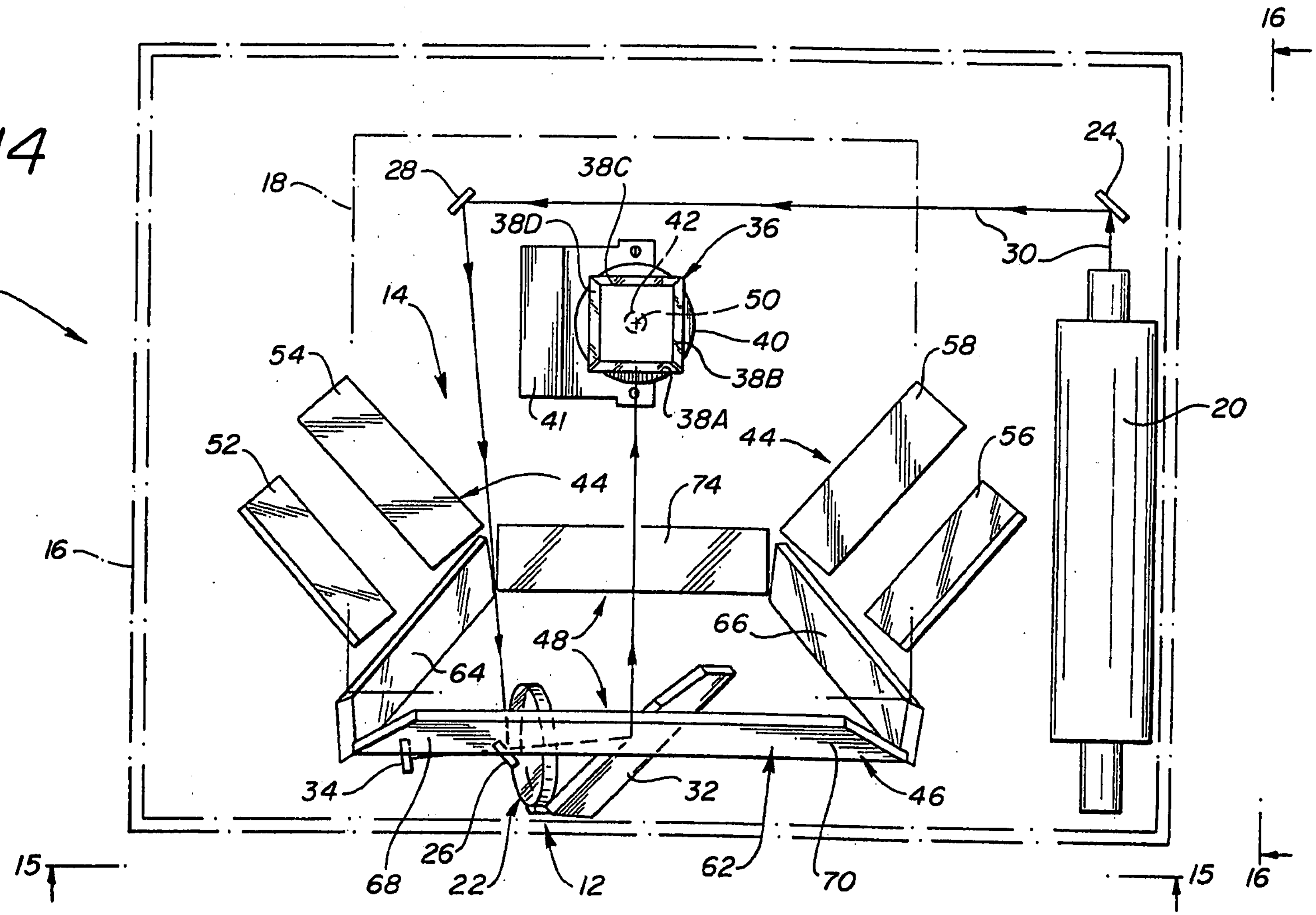
FIG-13

FIG-14



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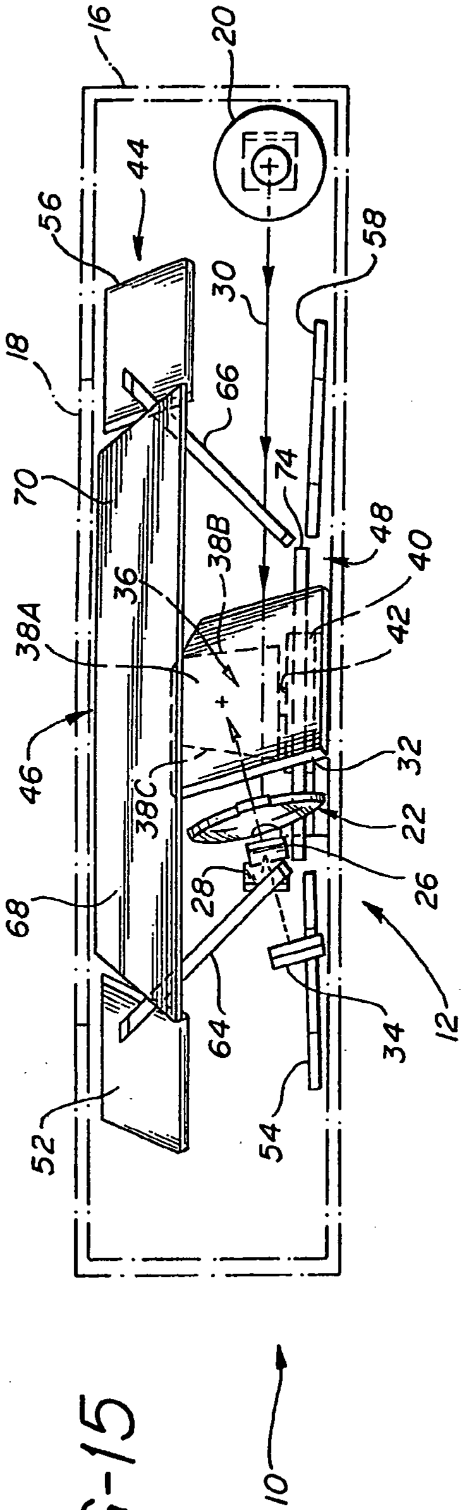
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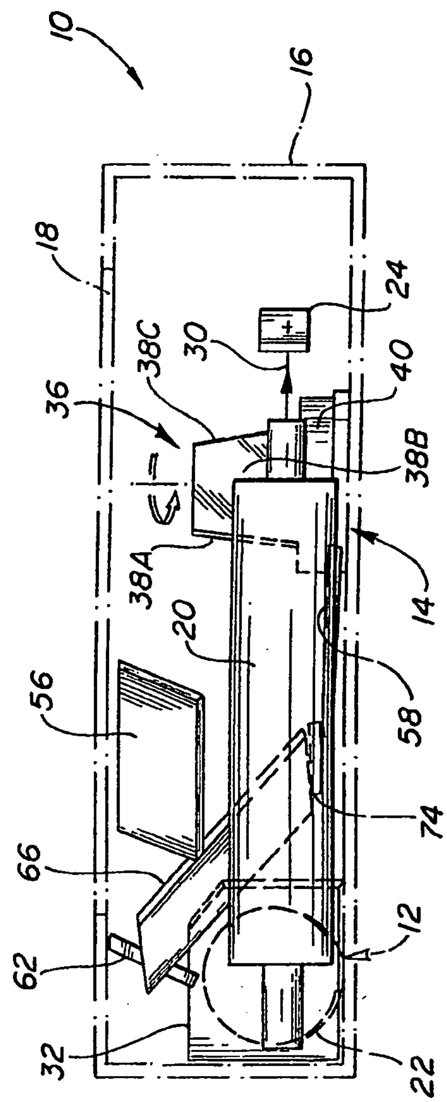
FIG-15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38C
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38B
38A
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22

FIG-16

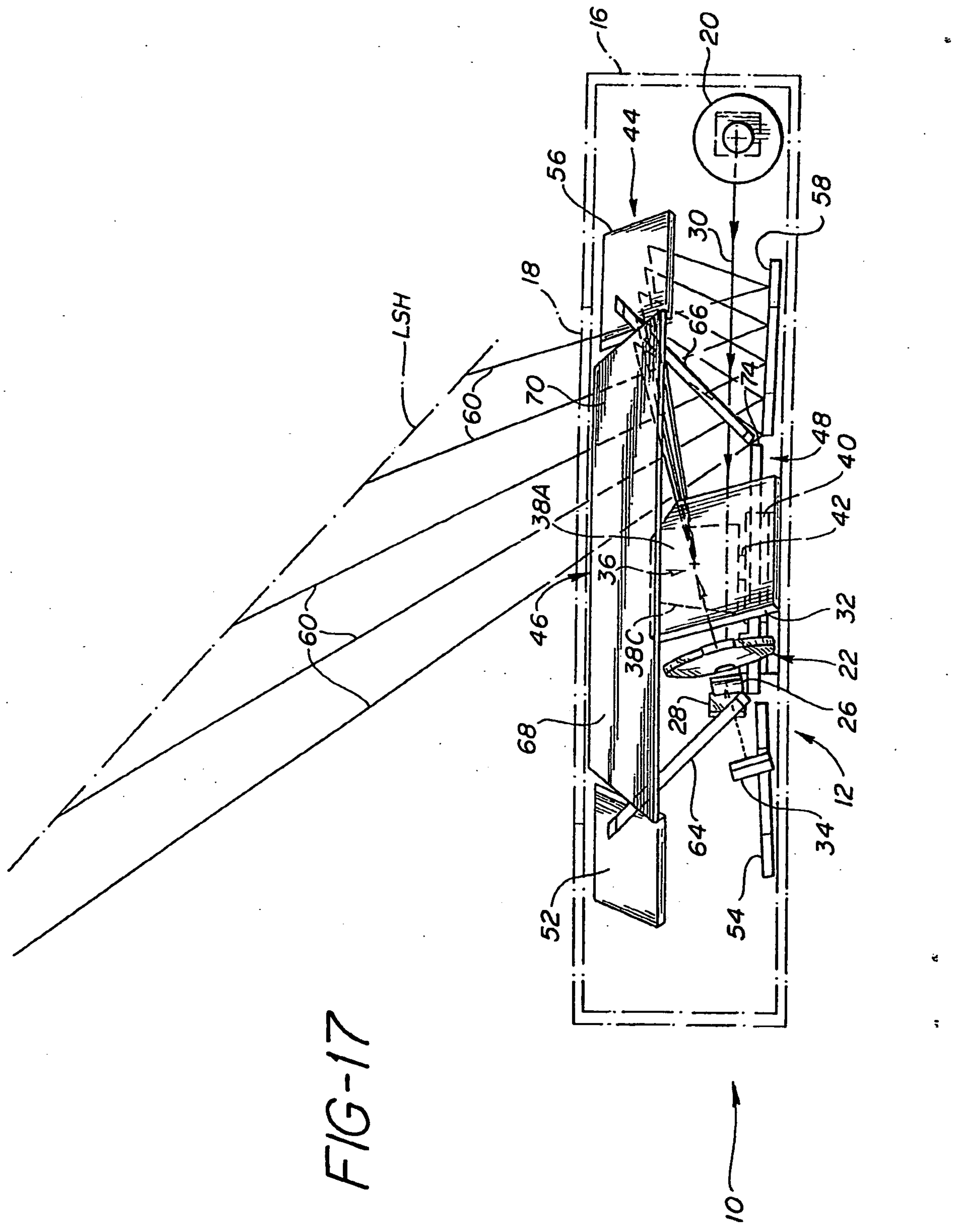
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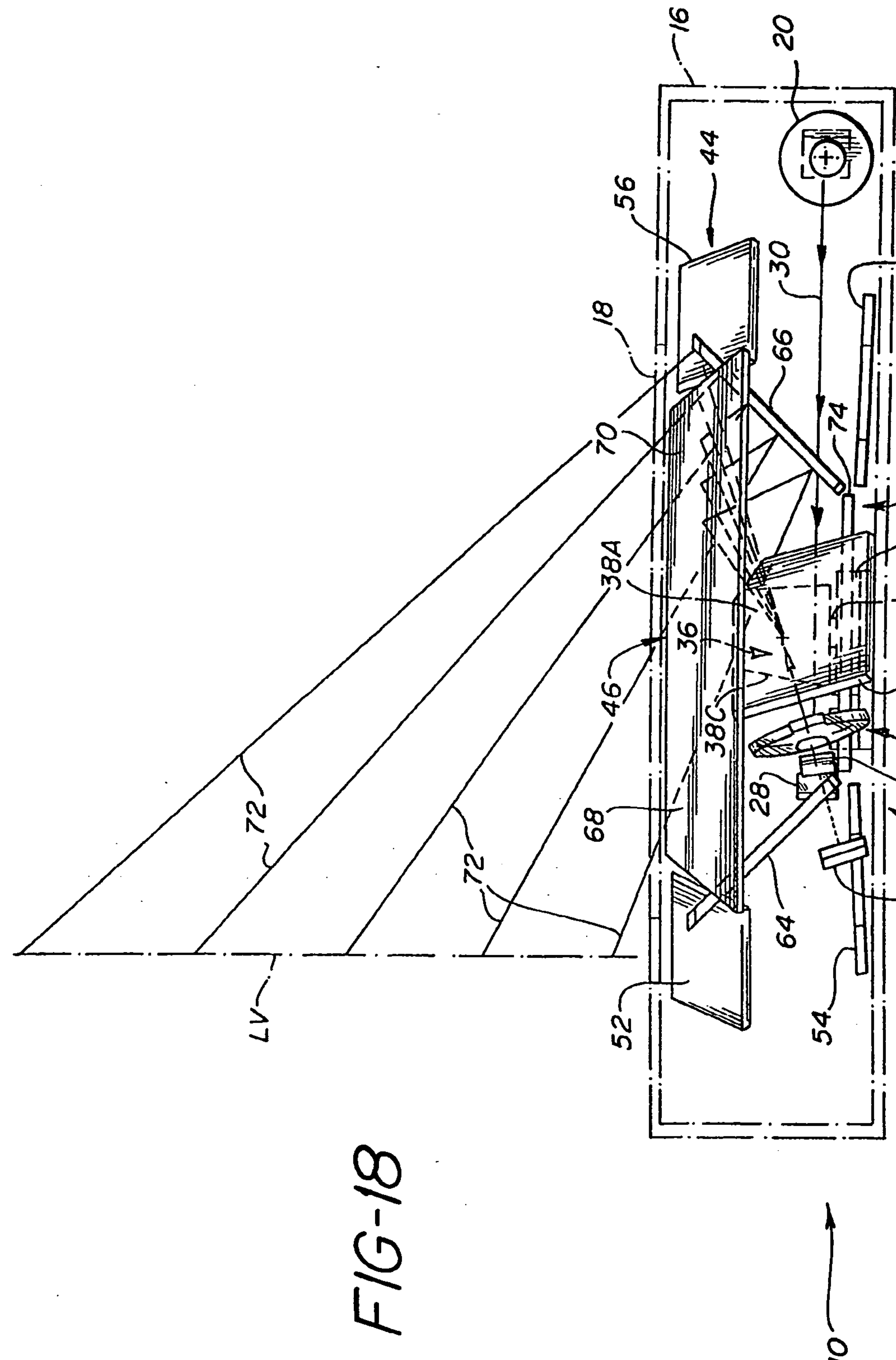
FIG-17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38A
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38C
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72
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72
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LV
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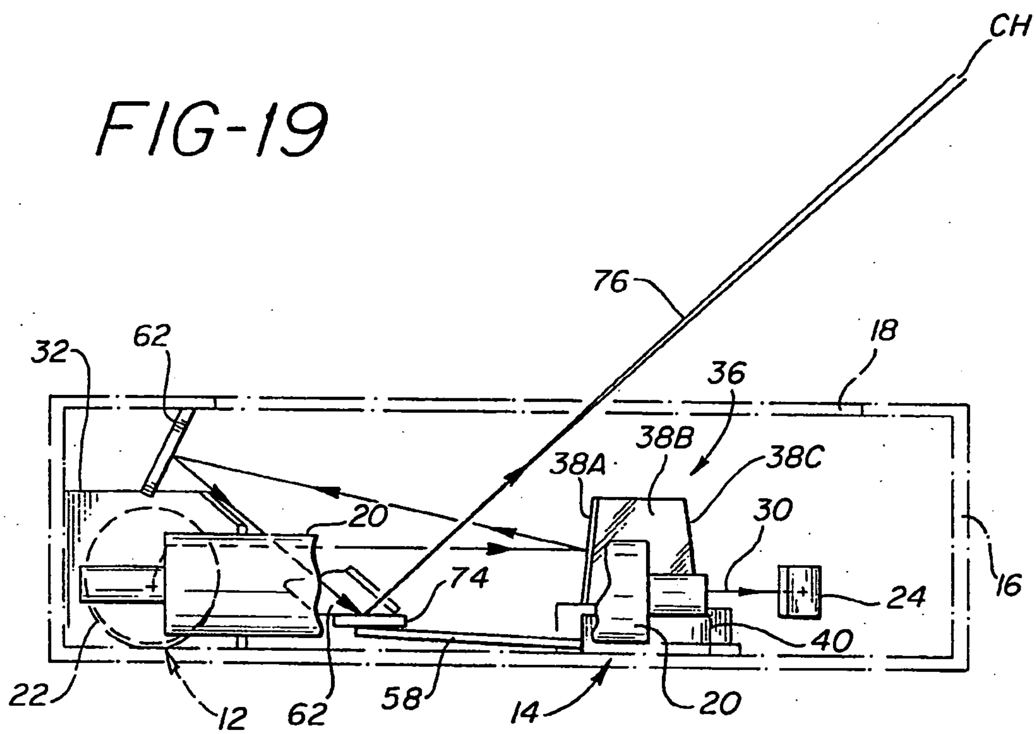
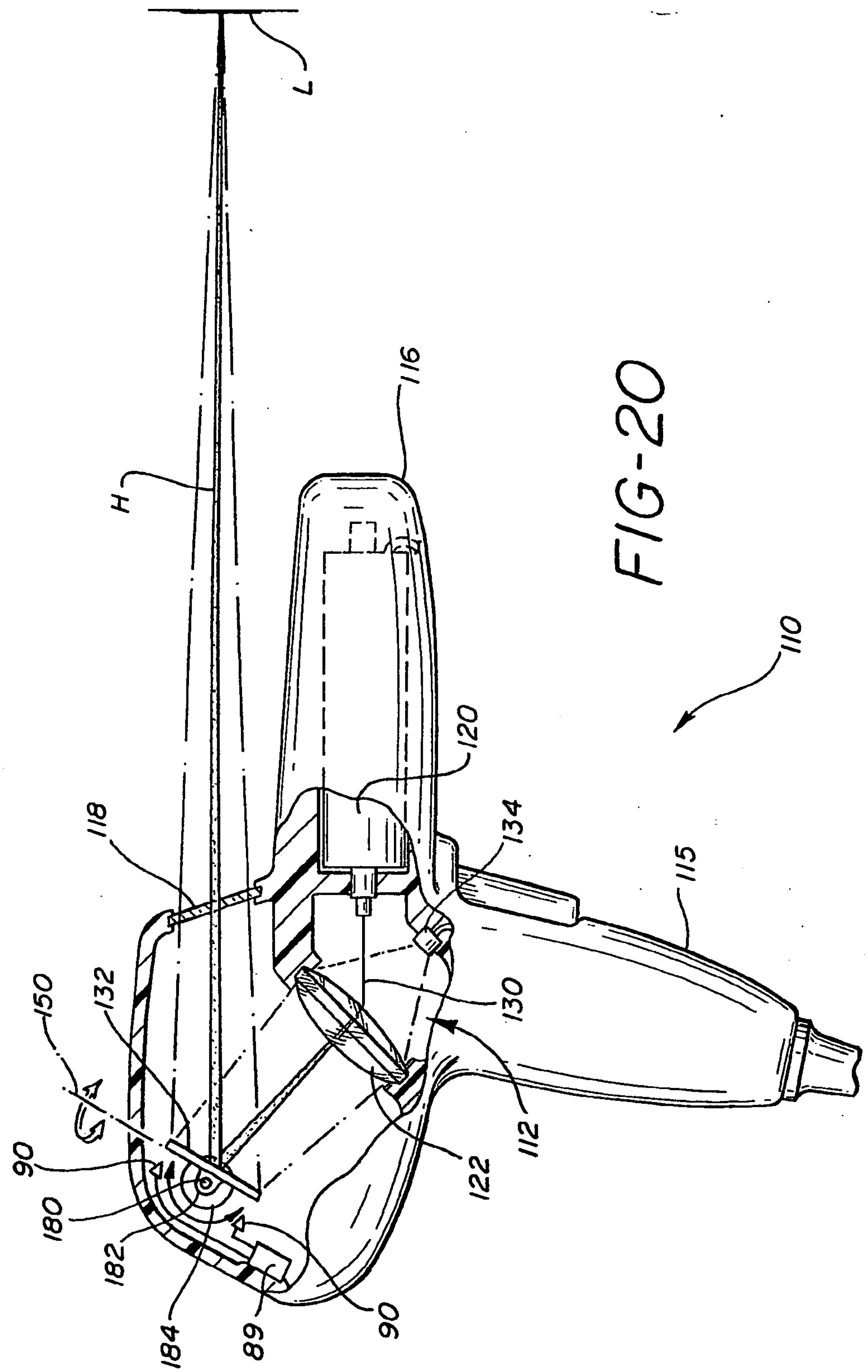
FIG-18

FIG-19




L
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184
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FIG-20

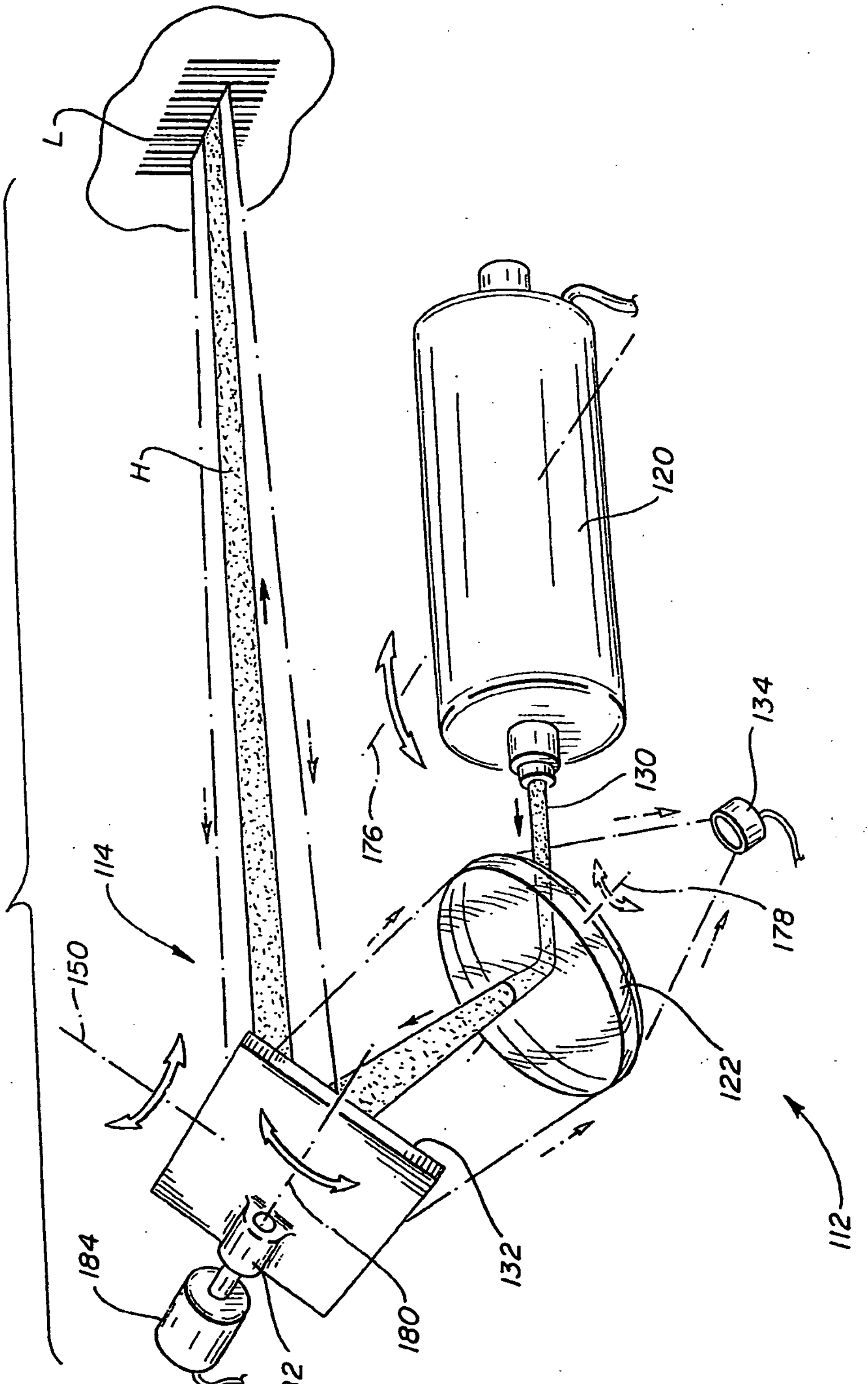
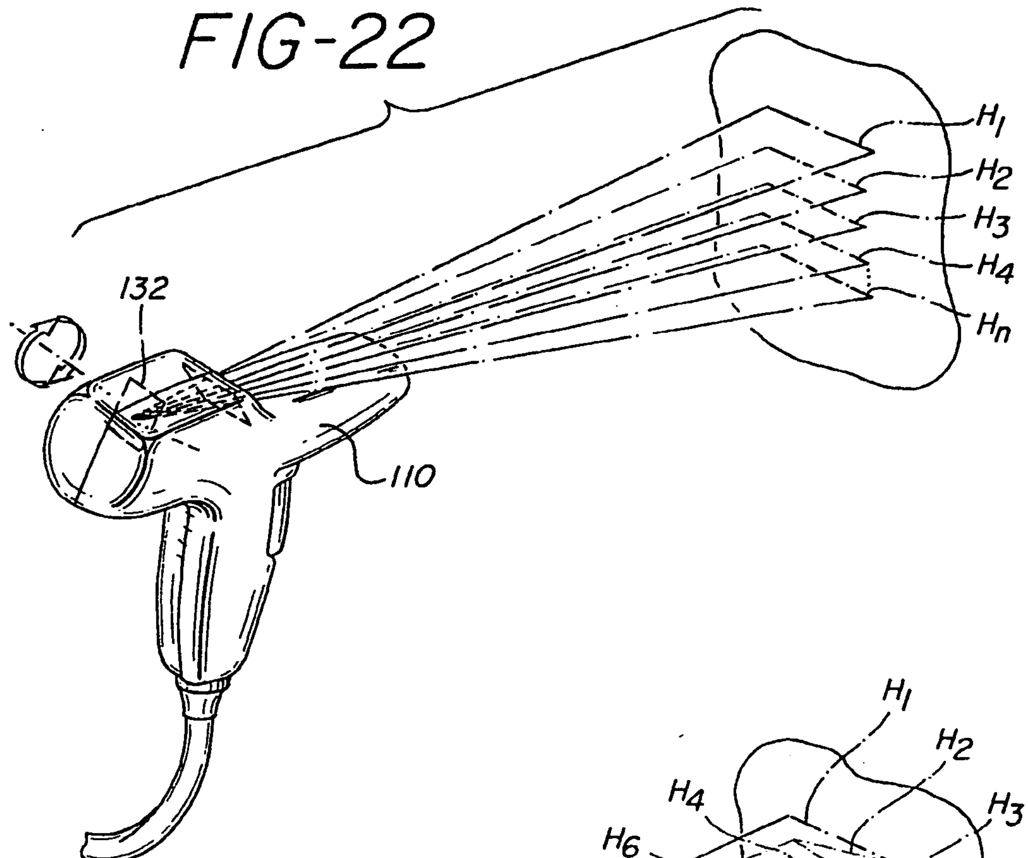


FIG-21

FIG-22



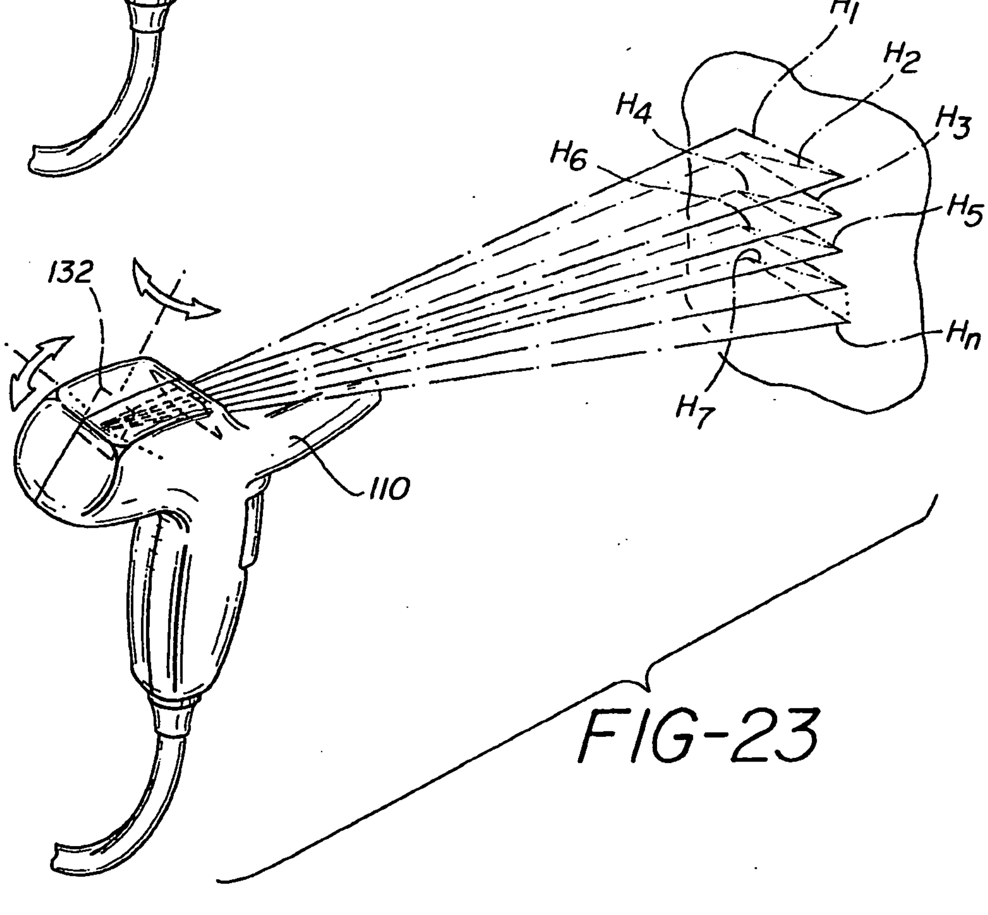


FIG-23

OPTICAL SCAN PATTERN GENERATING ARRANGEMENT EFFECTING ADDITIONAL SCAN LINES FOR A LASER SCANNER

Background of the Invention

The present invention generally relates to laser instruments and, more particularly, to an optical arrangement in a laser scanner for generating a scan pattern to find and read a bar code which is spaced from the scanner, such as a package label carrying a bar code symbol, wherein additional scan line segments are produced in the scan pattern to improve its ability to find and read a bar code.

Bar code symbols are used on a broad range of retail packages for check-out and inventory purposes and a variety of laser scanners have been designed to read such symbols. The basic requirement for grocery and other high volume transaction laser scanners is to operate in a way that the store check-out clerk does not have to worry about the label orientation as the product label is passed over the scanner. Thus, from the outset, efforts have been directed to producing a scan pattern with high probability of finding the bar code, and with low sensitivity to bar code orientation, as discussed by Hellekson et al, U.S. Pat. No. 4,799,194 (the '194 patent).

Those efforts have evolved to the point where most contemporary laser scanners produce scan lines based on a five apparent source scan pattern. The pattern produces five separate, fixed scan lines, appearing to come from five sources, but emanating, in fact, from a single source. Bar-coded articles move through the scan volume defined by the scanning beam planes. The bar code has a high probability of being intercepted, regardless of bar code orientation, by two orthogonally crossing scan lines in the five apparent source pattern. The five apparent source pattern has been recognized as a very efficient and elegant scan pattern which provides a high level of omnidirectional read capability for bar codes moving through the scanning beam planes.

By contrast, hand-held laser scanners typically continue to use single scan line patterns to read bar codes and, of course, rely on manual manipulation by the operator to find the bar codes.

Despite these efforts, the omnidirectional nature of laser scanners is still limited. Frequently, scanners fail to find and read the labels, requiring bar-coded articles to be moved repeatedly through the scan volume. In other instances, bar-coded articles do not physically lend themselves to being picked up by a person and brought across the scanner, and if left where they are, their labels may be positioned outside the scan volume. In such cases, hand-held scanners may be useful, but they too require a degree of precision in manipulation and, often, repeated attempts are needed to read a bar code.

Among prior art laser scanners are those discussed and disclosed in the '194 patent; compact scanners disclosed by Hellekson et al in U.S. Pat. No. 4,861,973 (the '973 patent), issued August 29, 1989; and hand-held laser scanners disclosed by Lonsdale et al, U.S. Pat. No. 4,678,288, issued July 7, 1987. Regardless of the embodiment, laser scanners typically have an optical system composed of transmission optics, collection optics and a scan pattern generating arrangement.

The transmission optics typically include a low power He-Ne laser, one or more small routing mirrors, a diverging lens, which may be on the end of the laser, and a focusing lens, which may be molded as part of a larger collection lens of the collection optics. The basic function of the transmission optics is to create and transmit a focused laser spot, of the correct diameter, at the plane of the package label to illuminate the bars and spaces of a bar code symbol on the label.

The collection optics typically include a collection lens, a bandpass filter and a photodetector. The basic function of the collection optics is to gather and collect only the diffuse laser light reflected from the label and focus it onto a small detector. The light is collected and focused in such a way

as to optimize the signal-to-noise ratio. For example, as known in the art, in a retro-directive optical system, a cone of light returning from the label and surrounding the beam of light being transmitted to the label is collected by the collection lens. In this way, a substantial portion of ambient light is eliminated from the system. Additional filtering of ambient light "noise" is achieved by the bandpass filter. Non retro-directive optical systems collect the diffuse, reflected basic light by other means known in the art.

The scan pattern generating arrangements of prior art laser scanners vary greatly. In a typical counter-top scanner, they employ an optical arrangement including a mirror assembly consisting of a plurality of primary reflective mirror surfaces which spin about an axis, and further include a multiplicity of secondary reflective elements. The basic function of the scan pattern generating arrangement is to move the beam of laser light through a three dimensional pattern capable of finding and reading labels in as many orientations as possible.

It is perceived that further improvements in performance and improved label reading capability are desired to satisfy the continuing demand for high performance, low cost scanners.

Summary of the Invention

The present invention provides an optical scan pattern generating arrangement in a laser scanner designed to satisfy the aforementioned needs. Moving by dithering, continuously rotating, or linearly translating a selected optical component or element of the scan pattern generating arrangement, in accordance with the present invention, improves the scanner's ability to find and read a bar code label by producing a plurality of related scan lines or scan line segments rather than single scan line. The term moving, thus comprises all types of motion which produce this effect, including dithering, rotating, and translating an optical element. Dithering is defined as

alternately rotating an element through an arc in different directions, or more simply reciprocating an element, typically in small amplitude motions. Dithering is, thus, distinguishable from continuously rotating an element through 360 degrees of motion. A scan line segment is defined as a portion of a scan line, and reference to scan lines is understood to include scan line segments. A scan pattern includes one or more scan lines.

Depending on the element moved or dithered in accordance with the present invention, a plurality of scan lines may be produced from the element in generally parallel relationship or non-parallel relationship. Regardless, production of a plurality of scan lines, compared to a single scan line, increases the probability of finding and reading a bar code passing through the scan volume. A scanner having one or more moving elements in accordance with the present invention, further permits many variations in scanner mounting arrangements and in the configurations for transporting bar-coded articles through the scan pattern, which are not possible with scanners of conventional design.

Therefore, the present invention is directed to an optical arrangement in a laser scanner for generating a laser light beam scan pattern in which at least one scan line of the scan pattern includes a plurality of related scan lines produced by moving at least one optical element. The present invention may be used in optical scanners having various configurations of optical elements, including without limitation counter-top and hand-held laser scanners. Thus, while the precise design of the scanner may vary, it is understood that moving an optical element, by dithering, rotating, or translating in accordance with the present invention, will produce the effect disclosed.

In a laser scanner, illustrative of counter-top laser scanners, the scan pattern generating arrangement comprises an optical device mounted for movement repetitively through a rotational cycle about a first axis and having a plurality of primary reflective elements in the form of primary mirrors

oriented in angularly displaced relation from one to the next about the first axis, means for rotatably moving the optical device about the first axis, and a multiplicity of secondary reflective elements also in the form of secondary mirrors being disposed in positions relative to one another and to each of the primary mirrors of the optical device as the primary mirror moves through a portion of each rotational cycle. Each primary mirror receives and reflects the laser light beam as the primary mirrors move successively through the portion of each rotational cycle of the optical device. Groups of one or more secondary mirrors are adapted to receive the laser light beam reflected from the primary mirrors and to reflect the same to trace scan lines of the laser light beam scan pattern at different orientations with respect to one another as the primary mirrors move successively through the rotational cycle portion. In accordance with the present invention means for moving at least one of the secondary mirrors about a second axis varies the orientation of the related scan line reflected therefrom, and produces a plurality of scan lines, rather than a single scan line. As before, means for moving may be means for dithering, means for rotating, or means for translating.

More particularly, the laser light beam scan pattern generated by the optical arrangement may be a single scan line pattern, or as is preferable for counter- top scanners, a five apparent source scan pattern, sometimes referred to as a "cross bar X" scan pattern. For the preferred five apparent source scan pattern for a counter-top scanner, the multiplicity of secondary mirrors may include first, second and third pluralities of the secondary mirrors. By way of example, not limitation, in an illustrative counter-top scanner, the secondary mirrors in the first plurality thereof are adapted to trace a pair of spaced apart side horizontal scan lines of the preferred five apparent source laser light beam scan pattern as the primary mirrors move successively through the rotational cycle portion. Specifically, the secondary mirrors in the first plurality include a pair of

upper and lower secondary mirrors disposed forwardly of and laterally outward from each of a pair of opposite sides of the optical device. Each primary mirror at an initial segment of each rotational cycle portion reflects the laser light beam to one of the pairs of upper and lower secondary mirrors to provide one of the side horizontal scan lines and at a final segment of the rotational cycle portion reflects the laser light beam to the other of the pairs of upper and lower secondary mirrors to provide the other of the side horizontal scan lines. More specifically, in the illustrative counter-top embodiment, each primary mirror at the initial segment of each rotational cycle portion reflects the laser light beam to the upper one of the one pair of secondary mirrors wherefrom the laser light beam is reflected to the lower one of the one pair and at the final segment of the rotational cycle portion reflects the laser light beam to the upper one of the other pair of secondary mirrors wherefrom the laser light beam is reflected to the lower one of the other pair.

Moving, by dithering, rotating, or translating one of the secondary mirrors along a second axis will cause corresponding reorientation of the related side horizontal scan line to a different plane. As the optical device typically rotates at thousands of revolutions per minute (rpm), moving the secondary mirror will produce a plurality of side horizontal scan lines at the target. The scan lines may be in generally parallel relationship at the target. Further, if one secondary mirror from each pair of secondary mirrors is moved, whether dithered, rotated or translated, a plurality of scan lines will be produced for each side horizontal scan line. Preferably, dithering, rotating, or translating a secondary mirror occurs at a rate which will produce a plurality of generally parallel scan lines spaced approximately 1/4 inches apart at the design distance for a target label. Where a plurality of secondary mirrors are moved, it is also preferable that such movement occurs in timed relation, so that the related scan lines of the scan pattern

shift together, maintaining their relationship in the pattern to the extent possible.

In the illustrative embodiment, the secondary mirrors of the second plurality thereof are adapted to trace a pair of spaced apart vertical scan lines of the preferred five apparent source laser light beam scan pattern as the primary mirrors move successively through the rotational cycle portion. Specifically, the secondary mirrors of the second plurality include an upper central secondary mirror disposed forwardly of the optical device, and a pair of outer secondary mirrors each being disposed forwardly of and laterally outward from one of a pair of opposite sides of the optical device and adjacent to and extending generally below one of a pair of opposite end portions of the upper central secondary mirror. Each primary mirror at an initial segment of each rotational cycle portion reflects the laser light beam to one of the end portions of the upper central secondary mirror wherefrom the laser light beam is reflected to one of the pair of outer secondary mirrors to provide one of the vertical scan lines and at a final segment of each rotational cycle portion reflects the laser light beam to the other of the end portions of the upper central secondary mirror wherefrom the laser light beam is reflected to the other of the pair of outer secondary mirrors to provide the other of the vertical scan lines.

In accordance with the present invention moving the upper central secondary mirror will correspondingly reorient both vertical scan lines to produce two pluralities of vertical scan lines. By contrast, moving one of the outer secondary mirrors will produce a plurality of scan lines from just the one outer secondary mirror without effecting the single vertical scan line produced from the other. Again such movement of the secondary mirrors preferably produces generally parallel scan lines spaced approximately 1/4 inches apart at the design distance for reading a target bar code label.

Finally, the secondary mirrors of the third plurality thereof are adapted to trace a center horizontal scan line of the preferred five apparent source laser light beam scan pattern as the primary mirrors move successively through the rotational cycle portion. Specifically, the secondary mirrors in the third plurality include the upper central secondary mirror of the second plurality of secondary mirrors, and a lower central secondary mirror spaced between and below the upper central secondary mirror and the optical device. Each primary mirror at a middle segment of each rotational cycle portion reflects the laser light beam to the upper central secondary mirror wherefrom the laser light beam is reflected to the lower central secondary mirror to provide the central horizontal scan line. In like fashion as aforesaid, moving, whether by rotating, or translating either the upper or lower central secondary mirror will produce a plurality of center horizontal scan lines, preferably in generally parallel relationship at the target.

The present invention further finds application in scanners which conventionally produce a single scan line. The arrangement discussed above, wherein a rotating optical device having primary mirrors generates scan lines by reflection off of secondary mirrors, may be used to produce a single scan line pattern, but is particularly suited to producing a multiple number of scan lines. Illustrative of single scan line scanners, is the optical scan pattern generating arrangement in a hand-held laser scanner. Such hand-held laser scanners may include various types of transmission and collection optics, and application of the present invention is not restricted to any one type. A typical scan pattern generating arrangement includes a fixed, primary optical element mounted in a stationary position and having at least one reflective or refractive surface, one or more secondary reflective elements in the form of secondary mirrors, a means for reciprocating one of the secondary mirrors along a third axis to trace a scan line, and in accordance with the present invention, a means for moving (by dithering, translating,

or rotating) at least one of the secondary mirrors along a second axis different from the third axis to produce a plurality of scan lines.

In the operation of a representative hand-held laser scanner, the primary optical element is adapted to receive and direct a laser light beam to a secondary mirror. A secondary mirror is adapted to receive the laser light beam from the primary optical element and to reflect the same. Reciprocating the secondary mirror with a dithering motion along the third axis causes the laser light beam reflected therefrom to trace a scan line. In accordance with the present invention, a secondary mirror is also moved along a second axis, by dithering, rotating or translating, to produce a plurality of related scan lines which, preferably, are in generally parallel relationship. The same secondary mirror may be both reciprocated along the third axis to produce the scan line, and moved along the second axis to produce a plurality of scan lines or segments. Alternatively, two secondary mirrors present in the arrangement may be separately reciprocated and moved to produce a plurality of scan lines.

Generally, regardless of the embodiment of the laser scanner in accordance with the present invention, a plurality of generally parallel scan lines may be produced from the optical scan pattern generating arrangement by varying the position or orientation of other parts in the arrangement. For example, in the two illustrative embodiments discussed above, the optical device or primary optical element of either arrangement could itself be moved along a second axis, preferably dithered or translated, to change the orientation of the laser light beam reflected therefrom. Alternatively, the laser itself or other elements of the transmission optics may be moved in accordance with the present invention to produce a plurality of scan lines.

Thus, for example, in the illustrative counter-top scanner embodiment where the optical device rotates about a first axis, its mounting may also be dithered about a second axis, not

aligned with the first axis, to vary the angle at which the laser beam is reflected to the secondary mirrors, and thereby produce a plurality of scan lines. Depending on the positions of the secondary mirrors relative to the primary mirrors, the plurality of scan lines produced by such dithering may or may not be in generally parallel relationship. Wobbling, rather than dithering, the mounting of the optical element, will wobble the first axis and produce a plurality of scan lines. However, in that case orientation of those scan lines in generally parallel relationship is problematic. In either case, moving the optical device, instead of rotating one or more secondary reflective elements, is not preferred.

Similarly, in the illustrative hand-held scanner embodiment which ordinarily produces a single scan line, the primary optical element which is ordinarily fixed, may be moved, preferably dithered, along a second axis different from the third to produce a plurality of scan lines which are preferably in generally parallel relationship. Dithering of the primary optical element along a second axis will change the angle at which the laser beam is directed to the secondary mirror, thereby causing scan lines reflected from the secondary mirror to be produced in different planes. However, because of the several functions which the primary optical element may perform in such scanners, such as focusing reflected laser light onto a detector in retrodirective collection optics, moving the primary optical element is also not preferred over movement of one or more secondary reflective elements because such movement destroys the retrodirectivity. When non-retro-directive optics are use, moving the primary optical element, or a part of the transmission optics, such as the laser or a routing mirror, is a viable alternative.

In a further alternative, applicable to optical scan pattern generating arrangements having a rotating optical device, a plurality of generally parallel scan lines may be produced by subdividing each of the plurality of primary reflective elements

into a plurality of facets. The facets are tilted relative to the first axis of rotation so as to be slightly offset from one another. Reflection off of the facets will change the plane in which the laser beam is incident upon the secondary mirror, causing the scan lines reflected from the secondary mirror to be produced in different planes.

In a still further embodiment of the present invention, moving a secondary mirror may simply comprise a manually adjustable means for mounting which may be used to fixably vary the position the secondary mirror. This manual positioning may be accomplished to orient the scan lines to accommodate different applications, for example, as where bar code labels are consistently presented on items at given heights, or where adjustment of the scan lines for vertical or horizontal reading is necessary. As well, manual positioning, while itself not practical for producing a plurality of generally parallel scan lines, may be used in combination with the moving of secondary mirrors, optical devices, primary optical elements, lasers or other parts of the transmission optics, discussed above, to shift the position in which a plurality of scan lines is generated or shift the orientation of the scan volume.

Various means for moving primary or secondary optical elements and the like, about or along a second axis may be used to achieve the object of the present invention. Initially, where secondary mirrors are moved, they must be fixed on axle assemblies or mountings which are adapted to dither, rotate, or translate and must be connected to a drive means for moving. Preferably the drive means is a direct current (d.c.) electric drive motor, mechanically connected to an axle assembly on which the secondary mirror is mounted. The electric motor may, however, be of any type, such as a stepper motor, brushless d.c. motor; alternating current (a.c.) servo motor, and others. Means for transmitting motion from the drive motor could be by direct connection or by intervening gears, belts, cams, linkages or other known mechanical means. It is understood that the drive

motor may be interconnected to drive both the optical device and one or more secondary mirrors. Alternative drive means for moving include any means for providing motion, for example, electromagnetic actuators such as solenoids, loudspeaker voice coils, pneumatic actuators such as air bladders, hydraulic actuators, electrostatic actuators and memory metals.

Where a secondary mirror is dithered or translated, rather than rotated, it is preferred to provide limit sensors, such as photoeyes, to limit the motion of the secondary mirror, and to provide a control circuit responsive to the limit sensors to control the operation of the means for moving. In addition, where two or more secondary mirrors are moved in accordance with the present invention, it is preferred that such motion be coordinated in timed relation to preserve the relative orientation between scan lines in the scan pattern, to the extent possible.

Because of the typically high rotational speed of rotating optical devices or the high speed of reciprocating primary optical elements, the speed at which the secondary mirrors may be moved by means for moving may be provided across a wide range, enabling the production of a greater or lesser number of generally parallel scan lines.

Accordingly, it is an object of the present invention to provide a laser scanner incorporating a laser light beam scan pattern arrangement which redirects a laser light beam to produce a plurality of scan lines in generally parallel relationship; to provide a first laser light beam scan pattern arrangement in which a multi-mirrored optical device rotates about a first axis and at least one secondary reflective element moves by dithering, rotating or translating along a second axis; to provide a second laser light beam scan pattern arrangement having a fixed primary optical element and at least one moving secondary element which by dithering, rotating, or translating about a second axis produces a plurality of scan lines rather than a single basic scan line; to provide dithering or wobbling of a primary optical

element about a second axis to produce in combination with one or more secondary mirrors a plurality of generally parallel scan lines instead of a pattern of single scan lines therefrom; to provide a rotatable optical device having multi-faceted primary mirrors and a multiplicity of secondary mirrors positioned relative to one another and to the successive primary mirrors of the rotatable optical device to trace one or more pluralities of scan lines in a scan pattern in different orientations with respect to one another so as to generate a multi-line scan pattern.

It is a further object of the present invention to provide, whether by dithering, rotating, translating or wobbling, means for moving an optical device, a primary optical element, or a secondary element to produce a plurality of scan lines in addition to those otherwise produced in conventional scanner arrangements; to provide a rotatable multi-faceted optical device to produce a plurality of generally parallel scan lines therefrom; and to provide a manually adjustable means for mounting an optical device, primary optical element, or secondary mirror to vary the range or orientation in which a scan line or plurality of scan lines is produced by a scanner.

Brief Description of the Drawings

Fig. 1 is a perspective view of an item carrying a bar code label sweeping across the window of a laser scanner.

Fig. 2 is a side view of the laser scanner and item of Fig. 1 sweeping across the window of the laser scanner.

Fig. 3 is a perspective view of an item carrying a bar code label passing by the window of a laser scanner along a conveying surface.

Fig. 4 is a side view of the item and scanner of Fig. 3 as it passes by the window of the laser scanner.

Fig. 5 is a perspective view of a counter top laser scanner and package disposed above the scanner and parallel to the front edge thereof and in a vertical position wherein a five

Fig. 17 is a schematic front elevational view similar to that of Fig. 15 also showing generation of side horizontal scan lines of the five apparent source scan pattern.

Fig. 18 is a schematic front elevational view similar to that of Fig. 15 also showing generation of vertical scan lines of the five apparent source scan pattern.

Fig. 19 is a schematic side elevational view similar to that of Fig. 16 also showing generation of the center horizontal scan line of the five apparent source scan pattern.

Fig. 20 is a side cross-sectional view of a hand- held laser scanner incorporating an optical arrangement for producing a plurality of scan lines in accordance with the present invention.

Fig. 21 is an enlarged partial schematic perspective view of the laser scanner of Fig. 20 showing a secondary mirror rotating in accordance with the present invention to produce one of a plurality of scan lines.

Fig. 22 is a schematic side view of the laser scanner of Fig. 20 showing a secondary mirror continuously rotating in accordance with the present invention to produce a plurality of discrete scan lines on a package in front of the scanner.

Fig. 23 is a schematic side view of the laser scanner of Fig. 20 showing a secondary mirror dither in accordance with the present invention to produce a plurality of scan lines in a zig-zag pattern on a package in front of the scanner.

Detailed Description of the Preferred Embodiment

Fig. 1 is a perspective view of an article A carrying a bar code label L, with a laser scanner S being used to scan the label. Typically, a clerk manually passes the product or item over a window W from which the scanning beam emerges so as to permit the beam to be swept across the label L, as in Fig. 2. A portion of the light reflected from label L passes downward from the arrangement of bars on label L. Figs. 1 and 2, thus, show the case where a single central horizontal scan line CH is

produced by the scanner S and the article A moves over the window W to encounter the scan line.

Reference is now made to Figs. 3 and 4 of the drawings which illustrate the production of a plurality of generally parallel scan lines, CH_1, CH_2, CH_3,...CH_n from a scanner 10 which is operated in accordance with the present invention. In referring to scan lines, it is understood that such reference includes scan line segments. Scanner 10 produces n scan lines, at least one of which finds and reads a target, such as bar code on label L, passing over or, as shown in Fig. 3, being conveyed beside scanner 10 on a conveying surface C. The plurality of scan lines CH_n, as opposed to a single basic scan line CH, produces a scanning volume of spaced, preferably generally parallel, scan lines at a target which increase the probability of finding and reading a bar code on label L passing through the scan volume, as shown in Fig. 4. Thus, as shown in Fig. 3, scanner 10 of the present invention, makes simpler scanners more versatile by producing a scan volume with higher probability of finding and reading bar codes on label L, and by enabling bar-coded articles to be passed through the scan volume by either passing over or passing beside the scanner, thus providing an added degree of design freedom. The latter arrangement is useful for scanning bar-coded articles which do not physically lend themselves to being picked up and brought across the scanner. It is preferred that the plurality of scan lines CH_n be in generally parallel relationship and spaced apart approximately 1/4 inches at the design distance for a target.

With reference to Fig. 5, where a plurality of intersecting scan lines are produced by a representative counter-top scanners, the laser beam is typically caused to rapidly sweep through a series of scan paths which collectively produce a scan pattern in which the likelihood of a successful scan is high. The scan pattern should be such that it is highly probable that at least one scan path will traverse the label in a direction more or less perpendicular to the bars of the bar code.

A common scan pattern in use in many scanners, is the five apparent source or "cross bar X" scan pattern shown in Fig. 5. The five apparent source scan pattern will be discussed to illustrate application of the present invention to scanners producing multiple scan lines, but such discussion is not intended to restrict the invention to such a scan pattern. Fig. 5 illustrates this scan pattern on a window W of the scanner S and on a face F of a package P, bearing a bar code label (not shown), disposed parallel to the front edge E of the scanner S and in a vertical position. The five apparent source pattern consists of five basic scan lines: the center horizontal (CH) line, right and left side horizontal (RSH & LSH) lines, and right and-left vertical (RV & LV) lines. Note the orthogonality of the RV and LV scan lines with the CH scan lines.

This scan pattern is recognized as a very efficient scan pattern as there will be least one set of perpendicularly crossing scan lines, despite the plane of the label, in different package orientations. Reference may be had to the '973 patent to Hellekson et al for additional discussion of such package orientations, incorporated herein by reference. The scan pattern, thus, increases the chances that a set of perpendicular lines will cross a label and provide a high level of omnidirectional read capability for bar codes moving through the scanning beam planes in the scan volume.

Reference is now made to Figs. 6 and 7 of the drawings which illustrate a laser scanner 10 in accordance with the present invention which produces a plurality of scan lines, preferably in generally parallel relationship, relative to one or more of the basic scan lines. In Fig. 6 a plurality of scan lines is produced generally parallel to each of the five basic scan lines of Fig. 5, while Fig. 7 illustrates a plurality of scan lines generally parallel to just one basic scan line in the five apparent source scan pattern. In each case the plurality of scan lines increases the probability of finding and reading a bar code passing through the scan volume, and enhances versatility of

design in scanning applications. As before, the plurality of generally parallel scan lines are preferably spaced at 1/4 inch intervals at the design distance for the target.

Reference is now made to Figs. 13-16 of the drawings which illustrate a representative laser scanner 10 having a retro-directive optical system which includes laser light transmission and collection optics 12 and the optical arrangement 14 of the present invention for generating a five apparent source scan pattern, such as the cross bar X scan pattern. The transmission and collection optics 12 and the optical arrangement 14 are enclosed in a housing 16 having an upper transparent window 18 in the top thereof. While the illustrative laser scanner 10 includes a retro-directive optical system, the type of transmission and collection optics 12 used is not critical to the present invention and other transmission and collection optics known in the art may be used.

The transmission and collection optics 12 of the laser scanner 10 include a laser source 20, for instance a helium-neon laser tube which produces a laser beam of red light at 632.8 nanometers (nm). Of course, other types of laser sources can be used. Optics 12 also includes a lens assembly 22 and three small routing mirrors 24-28 located, respectively, adjacent the output of the laser source 20, adjacent one side of the lens assembly 22, and intermediately therebetween for reflectively routing the laser light beam 30 from the laser source 20 to the lens assembly 22. The laser beam 30 emerges from the opposite side of the lens assembly 22 and is reflected by another mirror 32 oriented at approximately forty-five degrees to the beam path. The mirror 32 directs the laser beam 30 toward the optical arrangement 14 for generating the scan pattern for reading the target, as will be described in detail below. Light reflected back from the target along the same path via the optical arrangement 14 to the lens assembly 22 is collected and focused on a photodetector 34. Further description of optics 12 is not necessary herein for gaining a clear understanding of the present invention.

The optical arrangement 14 of the laser scanner 10 for generating the five apparent source light beam scan pattern basically includes a multi-faceted optical device 36 having multiple primary mirrors 38A-D, drive means for rotatably moving in the form a motor 40 on mounting 41 with a rotatable output shaft 42 for mounting the optical device 36, and first, second and third pluralities of secondary reflective elements, preferably first, second and third pluralities of secondary mirrors 44, 46, and 48, respectively. The motor 40 mounts the optical device 36 for rotational movement through a repetitive cycle about a generally vertical first axis 50. The primary mirrors 38A-D are oriented in angularly displaced relation, preferably ninety degrees, from one to the next about the first axis 50 such that the device 36 has a generally square cross-sectional configuration. However, the primary mirrors 38A-D are tilted about respective horizontal axes relative to the first axis 50 so as to create an optimum scan pattern. Although four mirrors 38A-D are illustrated, it will be appreciated that a different number of mirrors may be utilized in a scanner according to the present invention, such as for example two, three or five mirrors. Each primary mirror 38A-D is adapted to reflect the laser light beam 30 received from the mirror 32 of the transmission and collection optics 14 as the primary mirrors move successively through a portion of each rotational cycle of the optical device 36. As there are four primary mirrors 38A-D, the rotational cycle portion is equal to approximately 90 degrees. As each one of the primary mirrors receives the laser beam 30 from the mirror 32, it sweeps the laser beam 30 across all of the mirrors in the first to third pluralities 44-48 thereof. In this representative laser scanner design, each of the first to third pluralities 44-48 of secondary mirrors include at least one pair of mirrors, the first of which receives and reflects laser light beam 30 from the primary mirrors 38A- D, and the second of which reflects the laser light beam out through

window 18. Alternatively, the secondary reflection elements may be polygons, as shown in Fig. 10B

Reference is now made to Figs. 8 and 9, which show, in accordance with the present invention, means for moving the secondary mirrors of optical arrangement 14 to produce a plurality of generally parallel scan lines or scan line segments. For purposes of illustration, reference will be made to upper and lower secondary mirrors 51A and 51B, however, it is understood that such reference encompasses any secondary reflective element or secondary mirror. In accordance with the present invention, moving, by dithering, rotating or translating, a secondary mirror along a second axis 80 causes corresponding reorientation of the scan line produced therewith to a different plane. As optical device 36 typically rotates at very high revolutions per minute (rpm), typically thousands of rpm, moving a secondary mirror will produce a plurality of discrete scan lines in generally parallel relationship at the target. Preferably, movement of a secondary mirror occurs at a rate which will produce a plurality of generally parallel scan lines, spaced approximately 1/4 inches apart at the design target distance. Where two or more secondary mirrors are moved to produce two or more pluralities of scan lines related to or generally parallel to a basic scan line, it is preferable in a multi-scan line pattern that movement of the secondary mirrors is coordinated to maintain their relationship in the pattern, to the extent possible.

Fig. 8 illustrates the case where the second or lower secondary mirror 51B of a pair is dithered or rotated to reorient the reflected laser beam, while Fig. 9 illustrates the case where the first or upper secondary mirror 51A of a pair is dithered or rotated to reorient the reflected laser beam. Figure 12 illustrates the case where a secondary mirror 51A or 51B is translated to reorient the reflected beam. Rotating or translating a secondary or dithering the mirror 51A, 51B will produce similar results in hand-held scanners 110, as representatively shown in Figs. 22-23. Where the secondary

As shown in Fig. 9B, secondary reflective elements may be a multi-sided polygon 53, preferably rotating, to produce a plurality of scan lines as aforesaid. Use of a rotating polygon reduces the rotational speed otherwise required for rotating secondary mirrors.

Reference is now made to Fig. 10 of the drawings which illustrates an alternative means for producing a plurality of scan lines from the scanner 10. Means for varying, such as dithering the position of optical device 36 about a second axis 80 may be achieved by dithering motor mount 41 in the same manner as with the secondary mirrors aforesaid. Mechanical connection of a d.c. motor 98 to achieve this result is again preferred, although other drive means for moving are possible, as aforesaid. Depending on the positions of the secondary mirrors 51A, 51B relative to the primary mirrors 34A-34D, the plurality of scan lines produced by dithering optical device 36 may or may not be produced in generally parallel relationship. Means for varying may also cause optical device 36 to wobble the first axis 50 about which device 36 rotates. Such wobbling may be achieved, for example by rotating optical device 36 along a cam track (not shown) placed beside, below or between motor mount 41 and motor 40. Wobbling, rather than dithering the mounting of optical element 36 will also produce a plurality of scan lines, however, orientation of those scan lines in generally parallel relationship is problematic. Thus, means for varying, whether by dithering or wobbling, the position of optical device 36 is not preferred.

Referring now to Fig. 11, a further alternative, embodiment of optical device 36 is shown in which a plurality of generally parallel scan lines may be produced therefrom by subdividing each of the plurality of primary mirrors 38A-38D into a plurality of facets $38A_{1-n}$ to $38D_{1-n}$. The n facets of mirrors 38A-D are tilted about respective horizontal axes relative to the first, vertical axis 50, so as to be slightly offset from one another. Reflection off of the facets $38A_{1-n}$ to $38D_{1-n}$ will change

the plane in which the laser beam is incident upon the first secondary mirror 51A, causing the scan lines reflected from the second secondary mirror 51B to be produced in different planes.

Referring to Fig. 12, a plurality of generally parallel lines may be produced by translating secondary mirror 51A, 51B on track 95 along second axis 80. Preferably, drive motor 84 is attached to provide translational motion between limit sensors 90 in cooperation with control circuit 89.

In a still further embodiment moving, such as rotation, of a secondary mirror may simply accomplished by a manually adjustable means for mounting a secondary mirror, as representatively shown in Fig. 12. Various mechanical means may be provided for discrete adjustment of mountings 94. Such manual rotation or positioning of a secondary mirror may be used to orient the scan line to accommodate different applications, for example, as where bar code labels will be consistently passing at given heights, or where the scanner is installed in an existing structure and requires adjustment to direct the scan lines in the desired direction, or where the scanner is to be used variously for vertical and horizontal reading. As well, manual positioning, while itself not practical for producing a plurality of generally parallel scan lines, may be used in combination with the rotation of secondary mirrors, optical devices and primary optical elements by dithering, continuous rotation or wobbling to shift the position of the scan volume.

In yet another embodiment, the entire scanner 10 may be moved by dithering the scanner housing 16 which encloses the entire optical arrangement. The scan pattern produced by secondary elements fixed in the housing may thereby be varied in one or more directions to expand the scan volume. In this embodiment, all secondary elements are thereby moved about a second axis, as would be the transmission and collection optics 12.

Reference is now made to Figs. 13-16 where the impact of the present invention on representative laser scanner 10 may

be further understood. The mirrors in first plurality 44 thereof include right and left pairs of upper and lower secondary mirrors 52, 54 and 56, 58 disposed forwardly of, and laterally outward from, each of a pair of opposite sides of the optical device 36. The upper secondary mirrors 52, 56 are oriented at about thirty degrees with respect to vertical, whereas the lower secondary mirrors 54, 58 are oriented in a generally horizontal plane. Further, the upper secondary mirrors 52, 56 are located substantially above the optical device 36, whereas the lower secondary mirrors 54, 58 are located below it.

As shown in Fig. 17, the right and left pairs of upper and lower secondary mirrors 52, 54 and 56, 58 of the first plurality 44 thereof are adapted to receive the laser light beam 30 reflected from each of the primary mirrors 38A-D and to reflect the same along V-shaped laser light beam path 60 through the upper window 18 of the scanner housing 16 to trace the pair of spaced apart right and left side horizontal (RSH & LSH) scan lines of the five apparent source, cross bar X laser light beam scan pattern as the primary mirrors 38A-D move successively through the aforementioned portion of each rotational cycle of the optical device 36. Only generation of the LSH scan line by the left pair of upper and lower secondary mirror 56, 58 is depicted in Fig. 17. Movement of upper or lower secondary mirrors 56, 58, preferably by dithering or rotating, will produce a plurality of scan lines related to and preferably generally parallel to the basic scan line LSH, while similar movement of upper or lower secondary mirrors 52, 54 will produce a plurality of scan lines related to and preferably generally parallel to basic scan line RSH.

The secondary mirrors in the second plurality 46 thereof include an upper central secondary mirror 62 and a pair of outer secondary mirrors 64, 66. Shown best in Fig. 14, the upper central secondary mirror 62 at its opposite right and left end portions 68, 70 is disposed generally forwardly of the respective right and left pairs of upper and lower mirrors 52, 54

and 56, 58 of the first plurality 44. Also, the upper central secondary mirror 62 is disposed directly forwardly of and centered with the optical device 36. The right and left outer secondary mirrors 64, 66 are disposed laterally outward from opposite right and left sides of the optical device 36, and extending generally below and inwardly from the respective right and left end portions 68, 70 of the upper central secondary mirror 62. The upper central secondary mirror 62 is oriented about twenty-five degrees with respect to the vertical with its upper edge closer to the optical device 36 than its lower edge. The outer right and left secondary mirrors 64, 66 are tilted in opposite fashion with respect to one another being closest at their lower ends, and with each mirror oriented at about forty-five degrees with respect to the vertical.

As shown in Fig. 18, the upper central secondary mirror 62 and the right and left outer secondary mirrors 64, 66 are adapted to receive the laser light beam 30 reflected from each of the primary mirrors 38A-D and to reflect the same along V-shaped laser light beam path 72 through the upper window 18 of the scanner housing 16 to trace the pair of spaced apart right and left vertical (RV & LV) scan lines of the five apparent source laser light beam scan pattern as the primary mirrors 38A-D move successively through the aforementioned cycle portion of each rotational cycle of the optical device 36. Only generation of the LV scan line by the right outer secondary mirror 66 is depicted in Fig. 18. Movement of right outer secondary mirrors 66, preferably by dithering or continuous rotation, will produce a plurality of scan lines related to and preferably generally parallel to the basic scan line LV, while similar movement of left outer secondary mirrors 64 will produce a plurality of scan lines related to and preferably generally parallel to basic scan line RV. Movement of upper central secondary mirror 62, preferably by dithering or rotating, will produce a plurality of scan lines related to and preferably generally parallel to both basic scan lines RV and LV.

The secondary mirrors in the third plurality 48 thereof include the upper central secondary mirror 62 of the second plurality 46 and a lower central secondary mirror 74. The lower central secondary mirror 74 is oriented in a horizontal plane and is also spaced between and below the upper central secondary mirror 62 and the optical device 36.

As shown in Fig. 19, the upper and lower central secondary mirrors 62, 74 are adapted to receive the laser light beam 30 reflected from each of the primary mirrors 38A-D and to reflect the same along V-shaped laser light beam path 76 through the upper window 18 of the scanner housing 16 to trace the center horizontal (CH) scan line of the cross bar X laser light beam scan pattern as the primary mirrors 38A-D move successively through the aforementioned cycle portion of each rotational cycle of the optical device 36. Movement of either upper or lower central secondary mirror 62, or 74, preferably by dithering or continuous rotation, will produce a plurality of scan lines related to and preferably generally parallel to basic scan lines CH, as shown in Fig. 6. As upper central secondary mirror 63 is used in producing basic scan lines RV, LV and CH, it will be appreciated that moving its position in the representative optical arrangement 14 is preferred, as three pluralities of scan lines or scan line segments related to three basic scan lines will be produced while their relative orientation to each other will be generally maintained.

In like fashion where all scan lines result from reflection off of a common mirror, that single mirror may be moved, preferably dithered in accordance with the present invention to greatly increase the scanned area.

Further detailed discussion of the production of scan lines by the representative scanner 10 may be had by reference to such discussion by Hellekson et al in the '973 patent, which is incorporated herein by reference. Nonetheless, in view of the above-described layout of the first, second and third pluralities of secondary mirrors 44-48 relative to the primary mirrors 38A-D

of the rotating optical device 36, it can be readily understood how the different scan lines of the scan pattern can be generated at their different orientations as the laser light beam 30 is swept by each primary mirror across the secondary mirrors starting across the right upper secondary mirror 52, then across the upper central secondary mirror 62 from its right end portion 68 to right end portion 70, and finally across the left upper secondary mirror 56. It can further be readily understood how moving various secondary mirrors or of optical device 36 will produce pluralities of scan lines.

Reference will now be made to Figs. 20-22 of the drawings which illustrate a hand-held laser scanner 110, which in this example, has a retro-directive optical system which includes laser light transmission and collection optics 112 and an optical arrangement 114 for generating a single basic line scan line H. As shown in Fig. 20, the transmission and collection optics 112 and optical arrangement 114 are enclosed in a housing 116 having a lower handle portion 115 and a window 118. Laser scanner 110 is representative of hand-held laser scanners, as well as a further example of a laser scanner which produces a single scan line. Limitation of the present invention to such a scanner is not intended.

As best shown in Fig. 21, the transmission and collection optics 112 of laser scanner 110 include a laser source 120, for instance a helium-neon laser tube which produces a laser beam 130 of red light at 632.8 nm. Other types of lasers known in the art can be used. Optics 112 also includes a primary optical element, lens 122, which receives laser beam 130 and reflectively routes the beam towards a secondary reflective element, secondary mirror 132 which dithers about a first axis 150. Further description of optics 112 is not necessary for a clear understanding of the present invention. In that regard, to the extent that further detail is desired concerning the representative laser scanner 110, such may be understood by

reference to the disclosure of U.S. Pat. No. 4,678,288, to Lonsdale et al, which is incorporated herein by reference.

The optical arrangement 114 of laser scanner 110 simply comprises secondary mirror 132. As noted above, secondary mirror 132 may be moved, by dithering, rotating, or translating. As shown, secondary mirror 132 dithers by known means along first axis 150 to reflect laser beam 30 through window 118 and trace a single horizontal scan line H. In accordance with the present invention, secondary mirror 132 is moved by dithering or rotating along a second axis 180, as shown in Figs. 22 and 23, respectively, to produce a plurality of scan lines (or scan line segments) H_1 - H_n on different planes, preferably in generally parallel relationship at a target. Thus, as secondary mirror 132 reciprocates along a third axis 150, it may be further moved along second axis 180 by dithering, rotating or translating (not shown) its mounting 182. Mounting 182, as shown, is adapted to be dithered or rotated by drive means for moving, such as those discussed above, mechanically connected in like fashion as previously described. As shown in Fig. 21, a d.c. electric motor 184, mechanically connected to mounting 182, is preferred as means for moving secondary mirror 132 along second axis 180.

Rotating secondary mirror 132 along second axis 180 produces a plurality of scan lines H_1 - H_n, ones of which may or may not be in generally parallel relationship. Scan lines H_1 - H_n produced by dithering may resemble a continuous zig-zag shape, as shown in Fig. 23, depending on the speed of dithering, or when produced by continuous rotation may be a plurality of discrete scan lines, as shown in Fig. 22.

Alternatively, the primary optical element, lens 122, which is ordinarily fixed, or laser source 120 may be moved, preferably dithered, along a fourth axis 178 or fifth axis 176 shown in Fig. 21, to produce a plurality of generally parallel scan lines. Dithering of lens 122 or laser source 120 will change the angle at which the laser beam 130 is directed to secondary mirror 132, which would be reciprocating along third

axis 150 as before, thereby causing scan lines reflected from the secondary mirror 132 to be produced in different planes. However, because of the several functions lens 122 may perform in such scanners, such as focusing reflected laser light onto photodetector 134, moving, such as by dithering lens 122 is not preferred. Similarly moving laser source 120 is not preferred for the same reasons, as retro-directivity is destroyed. In a non-retrodirective laser scanner, however, moving lens 122 or laser source 120 are viable alternatives.

Regardless, in view of the above-described layout of the elements of laser scanner 110, it can be readily understood how scan line H and the different scan lines or scan line segments H_1-H_n can be generated.

It will be appreciated that the representative laser scanners used to illustrate the application of the present invention include optical arrangements which permit the generation of a scan pattern having a plurality of scan lines or scan line segments which may be generally parallel by rotating, whether by dithering or continuously rotating, optical elements, preferably secondary mirrors. The production of such pluralities of scan lines in accordance with the present invention facilitates the finding and reading of bar codes on targets, and makes possible the installation and use of scanners in more locations and orientations relative to target articles than was heretofore possible.

Having thus described the application of the present invention to two scan pattern generating arrangements in detail and by reference to a preferred embodiments thereof, it will be apparent that modifications and variations are possible without departing from the scope of the invention defined in the appended claims.

What is claimed is:

1. In a laser scanner, an optical arrangement for redirecting a laser light beam to produce a laser light beam scan pattern comprising:

an optical device mounted for movement repetitively through a rotational cycle about a first axis and having a plurality of primary reflective elements oriented in angularly displaced relation from one to the next about said first axis, each of said primary reflective elements being adapted to receive and reflect a laser light beam as said primary reflective elements move successively through a portion of each rotational cycle of said optical device;

means for rotatably moving said optical device about said first axis;

a first plurality of secondary reflective elements being disposed in positions relative to one another, said secondary reflective elements being adapted to receive the laser light beam reflected from said primary reflective elements as said primary reflective elements move successively through a portion of each rotational cycle, and adapted to reflect the same to trace at least one first scan line of the laser light beam scan pattern; and

means for moving about a second axis at least one of said secondary reflective elements of said first plurality thereof to vary the orientation of said scan line and produce a first plurality of spaced scan lines.

2. The arrangement of claim 1 in which said means for moving comprises means for dithering said at least one secondary reflective element.

3. The arrangement of claim 2 in which said means for dithering comprises:

means for mounting said at least one secondary reflective element, said means for mounting adapted to reciprocate;

drive means for moving connected to said means for mounting.

4. The arrangement of claim 3 in which said drive means are mechanically connected to said means for mounting by means for transmitting motion.

5. The arrangement of claim 3 further comprising: limit sensors adapted to limit the rotation of said means for mounting; and

control circuit means for controlling the operation of said drive means in response to said limit sensors.

6. The arrangement of claim 3 wherein said drive means comprises an electric motor.

7. The arrangement of claim 3 in which said drive means comprises an electromagnetic actuator.

8. The arrangement of claim 3 in which said drive means comprises an electrostatic actuator.

9. The arrangement of claim 3 wherein said drive means comprises a pneumatic actuator.

10. The arrangement of claim 3 in which said drive means comprises a memory metal.

11. The arrangement of claim 1 wherein said means for moving comprises manually adjustable means for mounting at least one of said at least one secondary reflective elements.

12. The arrangement of claim 1 in which said means for moving comprises means for rotating said at least one secondary reflective element.

13. The arrangement of claim 12 in which said means for rotating comprises:

rotatable means for mounting said at least one secondary reflective element;

drive means for moving said at least one secondary reflective element connected to said rotatable means for mounting for continuously rotating said at least one secondary reflective element.

14. The arrangement of claim 13 in which said drive means for moving comprises an electric motor.

15. The arrangement of claim 12 further comprising a control circuit means for controlling the operation of said means for moving.

16. The arrangement of claim 1 in which said means for moving at least one of said secondary reflective elements moves at least one of said secondary reflective element about a second axis.

17. The arrangement of claim 1 further including means for moving said optical device about a second axis not parallel to said first axis.

18. The arrangement of claim 1 wherein said means for moving at least one of said secondary reflective elements moves said secondary reflective element about a second axis to produce a plurality of scan lines in generally parallel relationship at a target.

19. The arrangement of claim 1 wherein said means for moving at least one of said secondary reflective elements moves said secondary reflective element about a second axis to produce a plurality of scan lines in generally diverging planes towards a target.

20. The arrangement of claim 1 further comprising:

a second plurality of secondary reflective elements being disposed in positions relative to one another, said second plurality of secondary reflective elements being adapted to receive the laser light beam reflected from said primary reflective elements as said primary reflective elements move successively through a portion of each rotational cycle, and adapted to reflect the same to trace at least one second scan line of the laser light beam scan pattern at a different orientation with respect to said first scan line of said scan pattern; and

means for moving at least one of said secondary reflective elements to vary the orientation of said second scan line and produce a related second plurality of scan lines within said scan pattern.

21. The arrangement of claim 1 in which said secondary reflective elements comprise mirrors.

22. The arrangement of claim 1 wherein said means for moving comprises means for translating at least one of said secondary reflective elements along a first axis.

23. In a laser scanner, an optical arrangement for redirecting a laser light beam to produce a laser light beam scan pattern comprising:

a primary optical element mounted in a stationary position and adapted to receive and reflect a laser light beam;

one or more secondary reflective elements disposed in positions relative to said laser light beam, and adapted to receive the laser light beam reflected from said primary optical element;

means for reciprocating at least one of said secondary reflective elements about a third axis to reflect said laser light beam to trace a scan line of the laser light beam scan pattern; and

means for moving at least one of said secondary reflective elements about a second axis to vary the orientation of said scan line and produce a plurality of scan lines.

24. The arrangement of claim 23 in which said means for moving comprises means for dithering at least one of said secondary reflective elements.

25. The arrangement of claim 23 in which said means for moving comprises means for rotating at least one of said secondary reflective element.

26. The arrangement of claim 23 in which said means for moving comprises means for translating at least one of said secondary reflective elements.

27. In a laser scanner, an optical arrangement for redirecting a laser light beam to produce a laser light beam scan pattern comprising:

an optical device mounted for movement repetitively through a rotational cycle about a first axis and having a plurality of primary reflective elements oriented in angularly displaced relation from one to the next about said first axis, each of said primary reflective elements being adapted to receive and reflect a laser light beam as said primary reflective elements move successively through a portion of each rotational cycle of said optical device;

means for rotatably moving said optical device about said first axis;

a plurality of secondary reflective elements being disposed in positions relative to one another, said secondary reflective elements being adapted to receive the laser light beam reflected from said primary reflective elements as said primary reflective elements move successively through a portion of each rotational cycle, and adapted to reflect the same to trace at least one scan line of the laser light beam scan pattern; and

means for moving said optical device comprising means for varying the alignment of said first axis about which said optical device is rotationally moved, said means for varying the alignment adapted to vary the angle of reflection of said laser light beam from said plurality of primary reflective elements to said secondary reflective elements, and produce a plurality of scan lines.

28. The arrangement of claim 27 in which said means for varying the alignment comprises means for dithering said optical device.

29. The arrangement of claim 27 in which said means for varying the alignment comprises means for wobbling said optical device.

31. An optical arrangement for redirecting a laser light beam to generate a laser light beam scan pattern including a plurality of scan lines, comprising:

an optical device mounted for movement repetitively through a rotational cycle about a first axis and having a plurality of primary reflective elements positioned about said first axis, each such primary reflective element being adapted to receive and reflect a laser light beam as said primary reflective elements move successively through a portion of each rotational cycle of said optical device;

means for rotating said optical device about said first axis;

a plurality of secondary reflective elements being disposed in positions with respect to each other and to said first axis, said secondary reflective elements being positioned such that each scan lines of said light beam scan pattern is produced by reflection of said beam by a unique set of two of said secondary mirrors; and

at least one of said unique sets of secondary mirrors further includes means for moving at least one of said secondary mirrors to vary the orientation of the related said scan line and produce a related plurality of scan lines within said scan pattern.

32. An optical arrangement substantially as hereinbefore described with reference to any of Figures 3, 4, and 6 to 23 of the drawings, or a laser scanner including such an optical arrangement.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition K) G3J (JB7WX); G4M (MBF)

(ii) Int CL (Edition 5) G02B

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Databases (see over)

(i) UK Patent Office

(ii)

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Documents considered relevant following a search in respect of claims 1-22, 31

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
AU X	GB 2101308 A (SICK)	1 at least
	GB 1597370 (SWEDA)	1 at least
	GB 464366 (MAGUIRE) See especially figure 10	1 at least
	EP 0295936 A2 (SPECTRA-PHYSICS)	1 at least
	EP 0224996 A2 (METROLOGIC)	1 at least
AU X	EP 0032117 A2 (SICK)	1 at least
	US 3995166 (COHERENT RADIATION) See especially mirrors 32, 54	1 at least
	US 3928759 (PITNEY BOWES) See especially figure 1	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

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